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# Longterm Memory in Complication-Free, Hypoglycemic, and Mild Respiratory Complications Preterm Infants

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# ABSTRACT

Longterm Memory in Complication-Free, Hypoglycemic, and Mild Respiratory Complications Preterm Infants

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The purpose of the research was to investigate learning and longterm memory in complication-free, hypoglycemic, and mild respiratory complication preterm infants and in fullterm infants 3 months after their expected date of birth using the mobile conjugate reinforcement paradigm. Experiment 1 attempted to replicate the reactivation effect with 30 fullterm infants assigned to a reactivation, no reactivation, and no training group. Infants in the reactivation and no reactivation groups were taught to kick to produce mobile movement on Days 1 and 2. On Day 15, the reactivation and no training groups were given a memory prompt. Longterm memory was assessed on Day 16 in a session procedurally identical to that of the training sessions of Days 1 and 2. There was no evidence of longterm memory in any group. Experiment 2 attempted to replicate the reactivation effect with an improved procedure. Twenty-four fullterm infants were assigned to the reactivation, no reactivation, and no training groups. Longterm memory was only shown by the reactivation group. In Experiment 3, 10 complication-free preterms, 8 hypoglycemic preterms, and 5 respiratory complication preterms were compared to 10 fullterm infants under the reactivation condition, which is the optimal remembering condition. The fullterm group in Experiment 3 did not show evidence of longterm memory. To obtain a better estimate of fullterm performance following reactivation, the data of Experiment 2 and 3 fullterm reactivation groups were combined. The preterm infants' performance was compared to that of the combined fullterm group. The findings suggested that ability to acquire the operant and to

remember it on a longterm memory test was not affected by prematurity. There was, however, evidence to suggest an impact of complications. Infants in the respiratory complication group were more likely to fail to meet the learning criterion, whereas infants in the hypoglycemic group were least likely to remember the association on the longterm memory test. They were also more irritable. These findings point to the need to investigate the differential impact of prematurity per se and specific complications.

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# TABLE OF CONTENTS

# LONGTERM MEMORY IN COMPLICATION-FREE, HYPOGLYCEMIC, AND MILD RESPIRATORY COMPLICATION PRETERM INFANTS

The purpose of the research was to investigate learning and longterm memory in complication-free, hypoglycemic, and mild respiratory complication preterm infants 3 months after their expected date of birth. Preterm infants, defined as infants born before 37 weeks gestational age (GA) are thought to be at greater risk for impairments than fullterm infants born at 40+/-2 weeks GA (Wolke, 1991). Numerous experimental and follow-up studies comparing preterm and fullterm infants at equivalent postconceptional age report evidence of poorer performance by preterm infants relative to that of fullterm infants. This is true of preterm and fullterm comparisons on physiological, behavioral, and cognitive measures at term, (i.e. 40 to 42 weeks postconception) (Howard, Parmalee, Kopp, & Littman, 1976; Aylward, 1982a; 1982b; Fox, 1983; Kurtzberg, Vaughan, Daum, Grellong, Albin, & Rotkin, 1979; Als, Duffy, & McAnulty, 1988; Duffy, Als, & McAnulty, 1990; Piper, Kunos, Willis, & Mazer, 1985), in infancy, and in childhood (Siegel, 1983; Siegel, Saigal, Rosenbaum, Young, Berenbaum, & Stoskopf, 1979; Field, Dempsey, & Suman, 1981; 1983; Crnic, Ragozin, Greenberg, Robinson, & Basham, 1983; Ungerer & Sigman, 1983; Caputo, Goldstein, & Taub, 1979). Studies of infant memory further suggest that preterm infants suffer impairments in certain aspects of memory functioning. More specifically, studies of visual recognition memory provide evidence of slower processing of information (Sigman, 1976; Rose, 1980; 1983) and greater difficulty in encoding relational information by preterm infants (Caron & Caron, 1981). There is also evidence of impaired learning and longterm memory in infants born prematurely (Gekoski, Fagen, & Pearlman, 1984).

While the findings from studies of infant memory are consistent with experimental and follow-up studies in that they suggest preterm infants are at risk for impairments, no conclusion can as yet be drawn concerning the effects of prematurity per se on memory functioning or other aspects of development, since to date in all but a few studies, the effects of prematurity have been confounded with those of the medical complications associated with prematurity and, at times, with those of social class. It could be argued that the differences seen between preterm and fullterm infants reflect the effect of complications and social class, and not that of prematurity. Alternatively, one might predict differences between preterm and fullterm infants even when preterm infants are free of complications. Turkewitz and Kenny (1982) have argued that premature birth in and of itself might force systems to become operational before they would normally have been ready, and that this might lead to different neural organization in preterm infants. Duffy, Mower, Jensen, and Als (1984) have also argued that the interaction of the preterm infant's immature system with the environment might stress the infant, causing opioid level changes which in turn might lead to changes in cortical function and development. The present research attempted to differentiate the effects of prematurity per se from that of complications associated with prematurity on memory functioning by comparing complication-free preterm infants and mild complications preterm infants of predominantly middle class families to fullterm infants of comparable social class on rate of acquisition, longterm retention, and cued retrieval of an operant response trained by means of conjugate reinforcement.

Evidence suggesting impaired memory functioning in preterm infants with a history of complications was first reported by Sigman and Parmalee (1974) using the novelty preference paradigm. This paradigm refers to a procedure whereby infants are first familiarized with a stimulus and are then shown the familiar stimulus paired with a novel stimulus. Memory for the familiar stimulus is assumed if infants show

preference (defined as longer looking time) for the novel stimulus over the familiar one. Sigman and Parmalee compared preterm and fullterm infants at 4 months corrected age (i.e. 4 months after their expected date of birth) on preference for complex, novel, and facelike visual stimuli. The preterm group had a mean GA of 33.6 weeks with a range of 27 to 36 weeks, but no information regarding their heaith status was provided. Given the low gestational age at birth of some of these infants and the fact that the authors did not report screening infants for complications, one can assume that at least some of the infants had suffered complications at birth. When total attention time was calculated, preterm infants were found to be similar to fullterm infants in preferring complex stimuli, but they differed from them in that they failed to show novelty preference and they were less attentive to facelike stimuli. Lack of novelty preference was interpreted by the authors as possibly indicating distortion in memory functioning in preterm infants. No mention was made concerning the possible effect on performance of complications associated with prematurity.

In a subsequent study, Sigman (1976) used the novelty preference paradigm to investigate the exploratory behaviors (manipulation and visual fixation) of preterm and fullterm infants at 8 months corrected age. Preterm infants in this sample had a mean GA of 33.5 weeks. Half of these infants were classified at risk on the basis of their performance on a battery of tests administered between birth and 9 months of age. No details were given, however, as to the nature of the medical complications suffered by preterm infants. Infants were presented with an object (a bell) for 6 minutes, after which time the familiar object was paired for 1 minute each with 1 of 10 novel objects for a total of 10 trials. Fullterm infants showed novelty preference on all 10 trials, whereas preterm infants looked at and manipulated the familiar stimulus longer than the novel stimulus for the first 2 trials. Novelty preference was, however, shown by preterm infants on subsequent trials. It was suggested that preterm infants require

more time to become familiar with an object. Again, no mention was made of the possible impact of complications on preterm infants' performance.

In a series of studies, Rose and her colleagues also used the novelty preference paradigm to compare preterm and fullterm infants' memory functioning. In a cross-sectional study, Rose, Gottfried, and Bridger (1979) investigated the effects of haptic cues on visual recognition memory in 6- and 12-month-old preterm and fullterm infants. The sample was predominantly of lower class families. The 6-month-old preterm group had a mean GA of 33.4 weeks and the 12-month-old preterm group had a mean GA of 33.2 weeks. Infants were screened for visual and neurological abnormalities. Each infant was tested under four conditions: the visual condition which involved visual inspection of a stimulus, the visual-haptic condition which allowed the infant to both look at and manipulate the object, the visual-haptic control condition where the object was encased in a transparent box and the infant could manipulate the box and visually inspect the object inside, and the visual control condition where the object was visually inspected while in the box. Familiarization with an object consisted of 20 s of accumulated looking time at the frontal perspective of the object. Following the familiarization phase, the stimulus was removed from the infant's view for 5 s and was then presented paired with a novel stimulus for a fixed 20-s visual test. Results showed that at 6 months, novelty preference was found only in fullterm infants under the visual and visual control conditions. At 12 months, evidence of memory was seen under all conditions for fullterm infants and under the visual and visual control conditions for preterm infants. The apparent change in preterm infants' memory functioning from 6 to 12 months, and the resemblance of 12-month-old preterm infants to 6-month-old fullterm infants on this task were said to reflect a delay in the development of some aspect of visual recognition memory in preterm infants.

To clarify the nature of the difficulties shown by preterm infants on tasks involving visual recognition memory, Rose (1980) conducted two other studies. In the first study, 6-month-old fullterm infants were compared to two groups of preterm infants, one of which had received extra tactile and vestibular stimulation on a daily basis while in the hospital nursery. Preterm infants were tested at 6 months corrected age. The "intervened" group of preterm infants had a mean GA of 32.7 weeks and the other preterm group had a mean GA of 33 weeks. As in her earlier work, preterm and fullterm infants were predominantly from lower class families and were again, only screened for visual and neurological abnormalities. Each infant was shown a multidimensional variations pattern (MD) for 5 s, pattern arrangements for 10 s, and faces for 20 s across three trials. After familiarizing themselves with a stimulus, infants were presented with the familiar and a novel stimulus for 10 s. Fullterm infants and "intervened" preterm infants showed recognition memory for both the MD and the facelike stimuli, whereas the other preterm group failed to differentiate the novel from the familiar stimuli on any of the trials. Rose (1980) then examined the effect of increased familiarization time on visual recognition memory in preterm infants at 6 months corrected age. Two groups of preterm infants, neither of which had received extra stimulation as neonates, were presented with the same 3 types of patterns as in the first study plus an additional pattern described as a Sun-Diamond pattern. One group of preterm infants had the same familiarization times as in the first study. The second group was given longer familiarization times of 20, 20, and 30 s for the MD, pattern arrangements, and face patterns respectively, and 20 s for the Sun-Diamond pattern. As with the first study, preterm infants given shorter familiarization times did not show recognition memory for any of the patterns. With longer familiarization times, however, recognition memory was shown for the MD, faces, and Sun-Diamond patterns.

These findings were interpreted as reflecting slower processing of visual information by infants born prematurely.

In a subsequent study, Rose (1983) both replicated and extended these findings. Preterm and fullterm infants were tested at 6 or 12 months after their expected date of birth. The 6- and 12-month group of preterm infants had a mean GA of 34.5 and 34.6 weeks respectively. The sample was again predominantly from lower class families and infants were only screened for visual and neurological abnormalities. All infants were tested under 4 conditions, with each condition differing in terms of familiarization time provided. The familiarization times were 10, 15, 20, or 30 s. At 6 months, fullterm infants showed recognition memory after familiarization times of 15, 20, and 30 s, whereas preterm infants only showed evidence of recognition memory with 30 s of study time. At 12 months, fullterm infants showed novelty preference with all familiarization times, while preterm infants only showed novelty preference with familiarization times of 20 and 30 s. These findings, which are consistent with those of previous studies by Rose and her colleagues, were said to support the notion of a developmental lag and possibly a deficit in preterm infants at 6 and 12 months in visual recognition memory, specifically with respect to the processing of visual information.

Caron and Caron (1981) investigated preterm and fullterm infants' ability to encode relational information. These authors argued that preterm infants' apparent memory difficulties might best be explained by an inability to encode relational information rather than poorer memory capacity or inefficient information processing abilities. Preterm and fullterm infants were compared at 12-, 18-, 21-, and 24 weeks corrected age. Fullterm infants were described as healthy, whereas preterm infants who had a median GA of 33 weeks and a median birthweight (BW) of 1620 g, were described as having suffered complications of varying severity. Infants were

habituated to the following 4 problems: faces; pairs of designs, with a small design above an identical, but bigger design; pairs of 2 identical visages; and photographs of women with a neutral facial expression. Following habituation, the infants were exposed to: novel faces and nonfaces; novel small designs over the same but bigger designs and big designs above small designs; novel pairs of identical and different visages; and novel photographs of women with a neutral expression and of smiling women. When the total fixation time across trials was computed, preterm infants were not found to be slower than fullterm infants on time taken to habituate. They did, however, require significantly more trials to habituate to the first of the four stimuli presented above, that of the faces. Preterm infants were also found to respond significantly more than fullterm infants to the component changes and significantly less to the configural changes. When presented with two novel stimuli, one arranged in a novel configuration and the other in a familiar configuration, preterm infants spent more time looking at the familiar configuration, whereas fullterm infants spent more time looking at the novel configuration. Preterm infants were also more likely than fullterm infants to show dishabituation to the novel items shown in a familiar configuration. These findings were said to reflect a deficiency in the content of preterm infants' information processing rather than a deficiency in information processing per se.

The preceding studies suggest that preterm infants with a history of complications are slower at processing information, have more difficulty encoding relational information, and have poorer memory functioning than fullterm infants of equivalent postconceptional age. The measure of memory used in these studies however, remains indirect and is based on the assumption that the preference for novelty implies recognition of the familiar item. Sophian (1980) has suggested that the novelty preference measure may confound memory and preference, in that infants may look at a familiar item more than at the novel item not because they have forgotten it, but because

they prefer it over the novel item. Similarly, infants might look at the novel item longer because they prefer it to the familiar item and not because they remember the familiar item.

Using operant conditioning, Rovee-Collier and her colleagues have developed a paradigm that provides a more direct measure of memory, specifically longterm memory. The basic paradigm involves two training sessions and a longterm memory test each of which includes a baseline, reinforcement, and extinction phase. During the reinforcement phase, infants are taught to kick to make a mobile move. Retention, referred to in this and the subsequent two experiments as recall and recognition, is then tested by measuring the number of kicks infants produce on a longterm memory test which is procedurally identical to the training sessions. Recall is assessed by calculating the number of footkicks infants produce in the presence of the mobile when kicking is ineffective in making the mobile move, whereas recognition memory is investigated when the infant's kicks produce mobile movement. Studies using the conjugate reinforcement paradigm indicate that 3-month-old fullterm infants whose kicking is reinforced by mobile movement increase their kick rate both during the training session and across sessions on successive days (Rovee & Fagen, 1976). With 2 training sessions, 3-month-old infants are able to remember the operant for as long as 8 days (Sullivan, Rovee-Collier, & Tynes, 1976). Under similar conditions, 2-month-old fullterm infants show evidence of having forgotten the operant after only 3 days (Greco, Rovee-Collier, Hayne, Griesler, & Earley, 1986). Moreover, after they show they have forgotten the association between kicking and mobile movement, both 2-month-old (Davis & Rovee-Collier, 1983) and 3-month-old fullterm infants (Rovee-Collier, Enright, Lucas, Fagen, & Gekoski, 1981; Sullivan, 1982) can retrieve the operant after 2 weeks if they are exposed to the mobile in motion (reactivation treatment) 24 hours prior to being tested for longterm retention.

The mobile conjugate reinforcement paradigm has only been used once with preterm infants. Gekoski, Fagen, and Pearlman (1984) compared a group of 10 preterm infants, who were judged by a neonatologist to have no major congenital, neurological, or physical abnormalities, to 10 fullterm infants. Although free of major abnormalities, preterm infants' scores on both the Obstetric Complication Scale and the Postnatal Factors Scale (Littman & Parmalee, 1974) were considerably lower than those of fullterm infants. In addition, preterm infants had a mean GA at birth of 31 weeks with a range of 26 to 36 weeks, and a mean BW of 1573 g, with 8 of the 10 infants being under 1800 g and 2 under 1000 g. These scores make it likely that these infants, although free of major abnormalities, had suffered from a variety of complications. Each infant was seen for three sessions which consisted of the following: a 3-minute nonreinforced mobile exposure, a 12-minute acquisition phase during which time footkicks were conjugately reinforced by mobile movement, and a 3-minute extinction phase. A 24-hour interval separated the first two sessions, whereas 7 days separated the second and third session. Evidence of acquisition was shown by fullterm infants in a single session, with acquisition being defined as infants' footkicks exceeding their baseline rate by 1.5 times. Preterm infants, on the other hand, did not acquire the operant until the last 6 minutes of the 12-minute training phase of the second session. Finally only the fullterm infants showed evidence of retaining the association between kicking and mobile movement 7 days after original learning. When GA at birth, BW, Obstetric Complications score, and Postnatal Complications score were correlated with the baseline ratio, significant positive correlations were obtained for all but BW. Then to assess the contribution of infants' birth status (preterm vs fullterm), partial correlations were used removing the effect of birth status. The only correlation that remained significant was that between the baseline ratio and the Postnatal Complications. The authors concluded that preterm infants were more likely to have lower

birthweights, had more obstetric complications, and were less likely to remember the operant than fullterm infants, and infants with severe postnatal complications showed poor retention regardless of their gestational age. They also stated that the performance of the 12-week-old preterm infants resembled that of 8-week-old fullterm infants, in that they were slower to learn the task and forgot it within one week. Preterm infants were therefore said to suffer from a developmental delay in their ability to acquire and retain a visually reinforced operant response.

Caution must be exercised, however, concerning these findings and their interpretation. According to the study, preterm infants were slower to acquire the contingency. This might be attributable to the direct effects on cognitive functioning of one or more postnatal complications for some of these infants, as well as the motor lag and lower energy levels of the very premature in the sample which would exist even when test dates were corrected for prematurity. A second point which also deals with the learning aspect of the task and which might affect retention is the fact that, unlike fullterm infants, preterm infants were not given much time to consolidate the acquired association. If acquiring the association is defined by 1.5 times the baseline level, then preterm infants had approximately 6 minutes to do so in the second session, whereas fullterm infants had 6 minutes in the first session and 12 minutes in the second session. The difference in the stability of the response reached by the fullterm and preterm infants prior to the longterm retention test might account for the differences in retention found between groups 7 days after training.

One may question the interpretation made by Gekoski et al. (1984) of a link between prematurity and a delay in the ability to acquire and retain a visually reinforced response. One must also question the interpretations made in other studies of a link between prematurity and slower information processing abilities (Rose, 1980;

1983; Sigman and Parmalee, 1974), or poorer relational information processing (Caron and Caron, 1981), since none of these studies controlled for the effect on performance of medical complications associated with prematurity. Little if anything is known concerning complication-free preterm infants. To date there have been only a few studies that have looked at even relatively healthy preterm infants at term (40 to 42 weeks postconception) and in infancy, and only one study that has investigated complication-free preterm infants and dealt specifically with memory functioning.

In one of the few studies which has looked at relatively healthy preterm infants at a corrected age equivalent to term, Als, Duffy, and McAnulty (1988) compared early-born (27-32 weeks GA) and later-born (33-37 weeks GA) preterm infants to fullterm infants at 42 weeks postconception on the Assessment of Preterm Infants' Behavior (APIB). All preterm infants were screened for major complications associated with prematurity: specifically, preterm infants were free of intraventricular hemorrhage, perinatal asphyxia, seizures, bronchopulmonary dysplasia, necrotizing enterocolitis, and unresolved retinopathy of prematurity. Early-born preterm infants had a mean GA of 30 weeks, a mean BW of 1392 g, and a mean 1-min Apgar score of 5.5, and 14 of 33 infants were judged to have mild hyaline membrane disease. Later-born preterm infants had a mean GA of 35 weeks, a mean BW of 2258 g and a mean 1-min Apgar score of 7.5. They were described as healthy, although 4 infants needed supplemental oxygen, and one was described as having mild hyaline membrane disease. The fullterm comparison group had a mean GA of 39.5 weeks, a mean BW of 3450 g, a 1-min Apgar score of 8.4, and were free of complications. Both preterm groups were found to be significantly different from the fullterm infants on autonomic, motoric, attentional, and state organization, as well as self-regulation, and examiner facilitation. The greatest discrepancy in performance was between the early-born preterm and fullterm infants. Early-born preterm infants showed moderate autonomic instability and reactivity,

moderate organization, moderate difficulties self-regulating, and considerable problems remaining alert. This was in contrast to the fullterm infants, who showed very mild autonomic reactivity and motoric disorganization, intermittent difficulties in state regulation, and moderate difficulties remaining alert. Later-born preterms' performance was like that of the early-born preterms, but less extreme. These findings were said to provide evidence of an effect on infants of being born prematurely, even when infants were free of major complications.

These researchers (Duffy, Als, & McAnulty, 1990) later compared a similar sample of early-born and later-born preterm infants to a sample of fullterm infants at 42 weeks postconception on the APIB, electrophysiological measures (Electroencephalogram (EEG) and Evoked Response (ER)), and the Postnatal Complications Scale. Preterm infants who were screened for intraventricular hemorrhage, perinatal asphyxia, seizures, hydrocephalus, bronchopulmonary dysplasia, clinically significant necrotizing enterocolitis, and persistent retinopathy of prematurity were described as free of "significant medical, genetic, and neurological problems". They were not, however, free of complications because preterm infants scores on the Postnatal Complications Scale were significantly lower than those of fullterm infants. Behavioral data from the APIB were consistent with Als, Duffy, and McAnulty's (1988) findings of poorer performance of early- and later-born preterm infants relative to fullterm infants on autonomic, motoric, state, attentional (visual and auditory orienting to animate and inanimate objects), and self-regulatory systems. Preterm infants also required greater examiner facilitation to reach optimal performance levels and to return to an integrated balanced state. Data from the neurophysiological measures showed preterm infants to be significantly different from fullterm infants on 17 features. When the effect of medical complications was statistically removed from the data, however, preterm infants were significantly

different from fullterm infants on autonomic, motoric, and self-regulatory systems of the APIB, but no longer differed on attention or state. Group differences on alpha feature in alert processing, and visual evoked responses at 1488, 276, and 1448-msec were maintained. The authors suggested that the few persisting differences between preterm and fullterm infants might reflect the impact of premature extrauterine experience on neural development. More specifically, they hypothesized that early exposure to sensory experience might trigger "critical periods" at a time when preterm infants were not equipped to incorporate sensory input, thereby leading to less than optimal neural development. They also hypothesized that the differences between preterm and fullterm infants was due to medical problems which had occurred but had not been accounted for. Similar conclusions might also apply to Als, Duffy, and McAnulty's (1988) findings.

In a study of attention, Fox and Lewis (1983) reported similar performance by healthy preterm and fullterm infants at 3 months corrected age. They compared cardiac response to auditory stimuli in three groups of 3-month-old infants: "healthy" preterm infants who had no major medical complications in the postnatal period, preterm infants who had Respiratory Distress, and healthy fullterm infants. Infants were habituated to binaural presentations of the phonemes "ba" or "pa". They then heard both phonemes presented simultaneously. No significant differences were found between "healthy" preterm and fullterm infants. Both groups showed cardiac orienting to the onset of the stimulation, they then habituated to the auditory stimulus, and showed recovery to the novel auditory stimulus. The RDS preterm group's response to the onset of the auditory stimulation was like that of the healthy preterm and term infants. Unlike these two groups, however, the RDS preterm group failed to habituate to the stimulus and did not dishabituate to the novel stimulus. The authors suggested that by 3 months corrected age, prematurity was no longer responsible for the RDS preterm infants' poorer

performance. Instead complications associated with prematurity were thought to account for the differences between groups.

In the only study of memory in complication-free preterm infants, Messmer, Taylor, and Papageorgiou (submitted for publication) failed to find differences between preterm infants screened for all complications (major and minor) and fullterm infants. They used a modified version of Cohen's (1976) visual habituation paradigm to compare memory and attentional processes in complication-free preterm and fullterm infants at 4 months corrected age. Infants were tested in their home three times within a 2-week period. During each visit, infants received 2 warm-up trials, 18 habituation trials, and 2 dishabituation trials under one of three conditions: 0-s, 2-s, and 3-s delay between the infant's orientation to a flashing light on the viewing panel on each trial and the tester's opening of a shutter to reveal the habituation pattern. Despite the increased demands placed on the infant's memory by longer delays, no significant differences were found between preterm and fullterm infants on any of the measures of attention or memory.

Although studies of preterm infants with complications consistently report poorer performance of preterm infants relative to fullterm infants, those of "healthy" and complication-free preterm infants suggest that at least on measures of attention and short-term memory, healthy preterm infants' performance is like that of fullterm infants. It may be that prematurity per se has an impact on infants' performance, but only in certain areas and/or at certain times early in the infant's development. To date there appears to be no evidence of an effect of prematurity per se on attention (Duffy, Als, & McAnulty, 1990; Fox & Lewis, 1983) and short-term memory (Messmer, Taylor, & Papageorgiou, submitted for publication). Whether prematurity per se is associated with deficits in longterm memory, however, remains unknown.

This study was therefore designed to investigate the effect of prematurity with and without specified mild complications on learning and longterm memory in infants 3 months after their expected date of birth. More specifically, we were interested in studying acquisition of an operant through conjugate reinforcement and retention over 24 hours and 2 weeks under optimal conditions for recall. The paradigm involved comparing three groups of preterm infants (complication-free, hypoglycemic, and mild respiratory complications) born between 32 and 36 weeks gestation and a group of complication-free fullterm infants given two 15-minute training sessions where they were taught to kick to make a mobile move and tested for recall two weeks later the day after receiving a memory prompt. Providing infants with a memory prompt is referred to as reactivation and is considered the optimal remembering condition (Sullivan, 1982). Preterm infants of less than 32 weeks gestation were excluded from the study because they are more likely to be different in energy level even if complication-free and tested at equivalent biological age. The complications chosen for study: hypoglycemia, which for preterm infants was defined as blood glucose level below 30 mg per cent (Klaus & Fanaroff, 1979); and mild respiratory complications, which included mild RDS, grunting, tachypnea, retractions of the chest wall, or cyanosis, are commonly associated with prematurity (Piekkala, Kero, Sillanpaa, & Erkkola, 1988), and are believed to put infants at greater risk for impairments. Neonatal hypoglycemia has been linked with impaired CNS functioning, reduced growth, and poorer performance on measures of intellectual functioning (Fluge, 1975; Pildes, Cornblath, Warren, Page-El, deMenza, Merritt, & Peeva, 1974; Ross, Kraus, & Auld, 1983). Respiratory complications such as Respiratory Distress Syndrome (RDS) have been associated with poor autonomic control hyperactivity, short attention span, as well as delays in mental and motor development, social maturity, and language production (Field, Dempsey, & Shuman, 1979; 1981; Field, Ting, & Shuman, 1979; Fox, 1983). In the hospital from

which we drew our sample, mild RDS has declined sharply in frequency, but hypoglycemia while treatable continues to occur and occurs as an isolated complication.

Fullterm infants were expected to learn the association between kicking and mobile movement within two training days. They were also expected to show evidence of memory at 24 hours and because of the reactivation treatment at 2 weeks as well. Given that preterm infants' GAs were at least 32 weeks, and they had only suffered mild respiratory complications or hypoglycemia, we expected these infants to have energy levels similar to that of fullterm infants. Consequently it was predicted that their ability to produce mobile movement would be like that of fullterm infants. In addition, given that 2-month-old fullterm infants learned to kick to make a mobile move (Davis & Rovee-Collier, 1983; Greco, Rovee-Collier, Hayne, Griesler, & Earley, 1986; Hayne, Greco, Earley, & Rovee-Collier, 1986; Rovee-Collier, Earley, & Stafford, 1989), we predicted that complication-free preterm infants at 3 months corrected age would acquire the response. Furthermore, we did not expect differences on learning between complication-free preterm and fullterm infants. In light of Gekoski, Fagen and Pearlman's (1984) findings, respiratory complications and hypoglycemic preterm infants were expected to require more time to learn the task and to have more difficulty remembering the operant.

Before beginning the main study, reported here as Experiment 3, a study was conducted to replicate the reactivation effect in 3-month-old fullterm infants. The procedure used was like that of Sullivan (1982), in that fullterm infants were tested under the reactivation, no reactivation, or no training condition. Infants in the reactivation and no reactivation groups were trained on the conjugate reinforcement task, whereas those in the no training group were simply exposed to the nonmoving mobile for two 3-minute periods and removed from their crib during the intervening

phase. Finally, the reactivation and no reactivation group received a prompt 24 hours prior to the longterm memory test. The reactivation and no reactivation groups were expected to acquire the operant in the first training session and remember it over 24 hours, but only the reactivation group was expected to show evidence of retention on the longterm memory test.

## Experiment 1

The purpose of Experiment 1 was simply to replicate Sullivan's (1982) finding that 3-month-old fullterm infants who are given two 15-minute training sessions can learn to kick to make a mobile move, and can remember the contingency two weeks after they have learned it, only with the help of a memory prompt 24 hours prior to the longterm memory test.

### Method

Subjects. Thirty 3-month-old fullterm infants were randomly assigned to one of three groups: a reactivation group, a no-training control group, or a no-reactivation control group. Each group included a similar number of male and female caucasian infants (5 males and 5 females in both the reactivation and no training groups; 4 males and 6 females in the no reactivation group) who were delivered vaginally (N = 8) or by Caesarian Section (N = 2). Scores on the Hollingshead Index of Social Position showed infants to be of middle class families (see Table 2). Most of the families were English Canadian: 9 of the 10 families in the no training and reactivation groups, and all 10 of the families in the no reactivation group. An additional 11 infants, 5 from the reactivation group (3 males, 2 females) and 6 from the no-reactivation control group (4 males, and 2 females) were lost for crying for more than 2 minutes (N = 8), falling asleep (N = 1), failure to learn (N = 1), and procedural error (N = 1). The 25% attrition rate is consistent with that found in previous studies (Greco et al., 1986: 29%; Davis & Rovee-Collier, 1983: 31%; Vander Linde et al., 1985: 29%).

Infants were recruited through birth announcements published in the major Montreal English-language newspaper between June, 1986 and June, 1988. Mothers of these infants were called, told about the study, and asked if they would be interested in

participating. If they agreed, they were asked questions to assess their infant's eligibility. In order to participate in the study, infants had to meet the following criteria: a gestational age (GA) between 38 and 42 weeks, a minimum birthweight of 6 lbs (2700 g), a 1-min and 5-min Apgar score of at least 7, no hearing or visual deficit, no heart problems, no asthma or allergies, no congenital anomalies, and no history of maternal complications during pregnancy. Infants born by Caesarian-Section (C-Section) were eligible only if the C-Section was done because of cephalopelvic disproportion (CPD), or simply because of a prior C-Section. Finally, mothers had to describe their infants as being in good health, as not having required hospitalization after the time of discharge, and not suffering from any infection at the time of the testing. Appendix A contains a copy of the consent form. Table 1 summarizes information on infant characteristics and Table 2 summarizes parental characteristics. One-way ANOVAs (see Appendix B ) revealed no significant group differences on either infant or parental characteristics.

Apparatus. The mobile used was a commercially available Nursery Originals hand-painted circus mobile, model 131-811 which has five wooden animal figures (see Rovee-Collier & Gekoski, 1979). Two L-shaped white metal supports of the type supplied with the mobile, with a clamp for the crib rail and a suspension hook for the mobile, were also used. A DYN-O-MITE infant seat model 441 was used to prop infants up in the reactivation visit. Videotaping was done with a Sony camera HVC 2200, a Sony Betamax videocassette recorder SLO340, and a Velbon tripod V6B32. Temperature was recorded with a Weston laboratory thermometer W1623 and humidity was measured with an Abbeon relative humidity indicator AB62B. Timing of visual attention was done with a Microntal LCD quartz chronograph. Viewing of the tapes was done from a Sony Trinitron color receiver/monitor CVM1900.

Procedure. The first of 3 or 4 home visits was scheduled as closely as possible to

Table 1

Infant Characteristics

| | Group | | |
|---|---|---|---|
| | No Reactivation | Reactivation | No-Training |
| Birthweight (grams) | | | |
| Mean | 3581.9 | 3274.2 | 3610.3 |
| S.D. | 373.1 | 219.7 | 603.9 |
| Range | 3175-4451 | 2948-3580 | 2693-4593 |
| GA (weeks/days) | | | |
| Mean | 39/3 | 39/1 | 39/3 |
| S.D. | 1/1 | 0/4 | 1/1 |
| Range | 38/0-41/5 | 38/1-39/5 | 38/0-41/3 |
| Apgar 1-min (5-min) | | | |
| Mean | 8.6 (9.3) | 8.2 (9.3) | 8.3 (9.1) |
| S.D. | 0.5 (0.5) | 0.8 (0.5) | 0.8 (0.3) |
| Range | 8-9 (9-10) | 7-9 (9-10) | 7-9 (9-10) |
| Chronological Age on Day 1 (weeks/days) | | | |
| Mean | 13/4 | 13/3 | 13/1 |
| S.D. | 0/6 | 0/6 | 1/0 |
| Range | 12/1-14/6 | 12/1-15/1 | 11/4-14/3 |
| Corrected Age on Day 1 (weeks/days) | | | |
| Mean | 13/2 | 12/5 | 12/6 |
| S.D. | 0/4 | 0/3 | 0/3 |
| Range | 12/2-14/3 | 12/0-13/1 | 12/2-13/5 |

Table 2

Parental Characteristics

| | Group | | |
|---|---|---|---|
| | No Reactivation | Reactivation | No-training |
| Maternal Age (yrs) | | | |
| Mean | 29.8 | 30.8 | 30.8 |
| S.D. | 3.8 | 2.9 | 2.9 |
| Range | 24-36 | 28-36 | 28-36 |
| Paternal Age (yrs) | | | |
| Mean | 33.7 | 33.8 | 34.4 |
| S.D. | 3.4 | 4.7 | 4.9 |
| Range | 27-39 | 29-42 | 27-42 |
| Maternal Education (yrs) | | | |
| Mean | 15.3 | 14.0 | 12.8 |
| S.D. | 3.6 | 2.8 | 1.9 |
| Range | 11-24 | 11-18 | 11-16 |
| Paternal Education (yrs) | | | |
| Mean | 15.3 | 14.0 | 13.3 |
| S.D. | 3.6 | 2.7 | 2.7 |
| Range | 11-23 | 11-18 | 11-18 |
| Hollingshead Index of Social Position | | | |
| Mean | 2.2 | 2.8 | 2.9 |
| S.D. | 0.9 | 0.9 | 0.9 |
| Range | 1-4 | 2-4 | 2-4 |

13 weeks (permissable range 12 weeks 0 days to 14 weeks 3 days) after the infant's expected date of birth at a time of day deemed by the mother to be an alert-play period for her infant. While the time of day varied across infants, it remained the same across visits for each infant. Temperature and humidity were recorded at each visit to verify that differences in these environmental measures did not affect infants' energy level and thus affect their kick rate. No significant differences in temperature or humidity were found between groups or test sessions (see Appendix C)

Upon arriving at the infant's home, the mother was given a consent form describing the study. Once she had read it, she was given the opportunity to ask questions concerning the study. When all questions had been addressed, the equipment was brought to the infant's crib and set up. The camera was placed at the foot of the crib. Two L-shaped suspension hooks were clamped to the sides of the crib and placed opposite one another. The mobile was suspended from one of the hooks and the other hook remained empty. The infant was then placed supine in the crib with the mobile hanging above its upper chest. A ribbon was looped around the infant's right ankle. For the first and last 3 minutes of a 15-minute procedure, the ribbon was connected to the empty hook. During this time, movement of the infant's right leg did not cause the mobile to move. In the intervening 9 minutes or reinforcement phase, the ribbon was switched from the empty hook to the hook from which the mobile hung, and movement of the right leg now produced movement of the mobile. The reinforcement phase was only given to infants in the reactivation and no-reactivation groups. Infants in the no-training control group, on the other hand, were removed from their crib during this 9-minute period. Two such visits (Day 1 and Day 2) were scheduled for each infant 24 hours apart.

Thirteen days after the second visit, or Day 15 of testing, infants in the reactivation and familiarization groups were shown the mobile in motion for 3 minutes.

This is known as the Reactivation Phase of the experiment. As with the initial two visits, two L-shaped hooks were attached to opposite sides of the crib and the mobile was hung from one of the hooks. A ribbon was connected to the mobile and draped over the side of the crib. Infants were then seated in an infant seat and placed in their crib so that the mobile hung at approximately the same distance from their eyes as it had been when they were lying supine. The change in the infant's position was to hinder new learning and prevent kicking during the reactivation visit (Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980). The experimenter then hid from the infant's view and pulled the ribbon so that the mobile moved at the same rate as that produced by the infant in the last 3 minutes of the 9-minute reinforcement phase of the second visit. Since infants in the familiarization group did not experience reinforced kicking in the first two visits, the rate of movement for these infants was determined by a yoked control procedure. Therefore subject 1 in the familiarization group was shown the mobile moving at the rate produced by subject 1 in the reactivation group, and so on for all 10 subjects.

All infants were given a longterm retention test 14 days after the second visit took place, or Day 16 of testing. Procedurally, the retention test was identical in all respects to that of the Day 1 and Day 2 training visits for the reactivation and no reactivation groups.

Footkicks were later scored from videotapes by the experimenter and a trained rater who was blind to the experimental hypotheses, the infant's group membership, and the visit being viewed. A footkick was scored if the infant's right foot moved vertically or horizontally and at least partially retraced its original path in a smooth, continuous motion (Rovee & Rovee, 1969). Reliability was established by calculating for each infant session % agreement between raters on the number of footkicks produced in each minute of the 15-minute procedure. Rater reliability for the footkick data was 83%. Only those scores produced by the blind rater were used in the footkick analyses. Visual

attention was then scored by this same rater. Visual attention was recorded when the infant's head and eyes were oriented in the direction of the mobile. The mobile was not in view on the videotape. Twenty percent of the sessions were scored for visual attention by both the experimenter and the blind rater. Rater reliability for the visual attention data was 91%.

Once the videotapes were scored, the data were reviewed to verify that infants had met the learning criterion of kicking 1.5 times their baseline level for 2 of 3 consecutive minutes (Rovee-Collier, Earley, & Stafford, 1989). The learning criterion used in this and subsequent studies differed from that of previous studies, however, in that infants who met the learning criterion during the extinction phase of training were not excluded. These infants were thought to have acquired the operant because inspection of the data suggested that what was seen in extinction was simply the culmination of a learning process. In Experiment 1, 1 infant in the reactivation group met the learning criterion during the extinction phase.

## Results

Each infant's Day 1 baseline score was inspected to verify that infants kicked at least 2 kicks per minute prior to training. Infants whose baseline value was less than 2 kicks per minute had their baseline score increased to 2 kicks per minute. This was done to reduce the likelihood that infants would meet the learning criterion by chance. Subsequent analyses were computed using the changed score. The footkick data of blocks 1 to 5 of Days 1, 2, and 16, and the visual attention data of Days 1, 2, 15, and 16 were then subjected to Levene's test of homogeneity of variance. This test was used because unlike other tests of homogeneity of variance, it is not sensitive to departures from normality and more importantly, it allows one to measure the impact of treatment on group variance (Keppel, 1973; Stevens, 1986). To compute Levene's test, the data were transformed to Z scores and subjected to an ANOVA. Unless significant, results of Levene's test of homogeneity of variance are not reported in the text but are found in the appendices.

The acceptable level of significance for all analyses in this and the two subsequent studies was set at .05. Findings at the .10 to .15 level of significance are, however, also reported. Stevens (1986) suggests that when dealing with small n's, we need to increase the power of our test and we should consider findings significant at the .10 to .15 level as important. Finally, whenever post hoc tests were deemed necessary, the Tukey Honestly Significant Difference (HSD) test was used, because it provides adequate protection against Type I errors without overcorrecting.

Preliminary Analysis of Footkick Data. The reactivation, no reactivation, and no training groups' Day 1, 2, and 16 footkick data are found in Appendix D and are shown in Figure 1. Inspections of the footkick data revealed that one infant in the no training group kicked less than 2 kicks per minute in the baseline period. This infant's baseline score was therefore increased to 2 kicks per minute. There also appeared to be

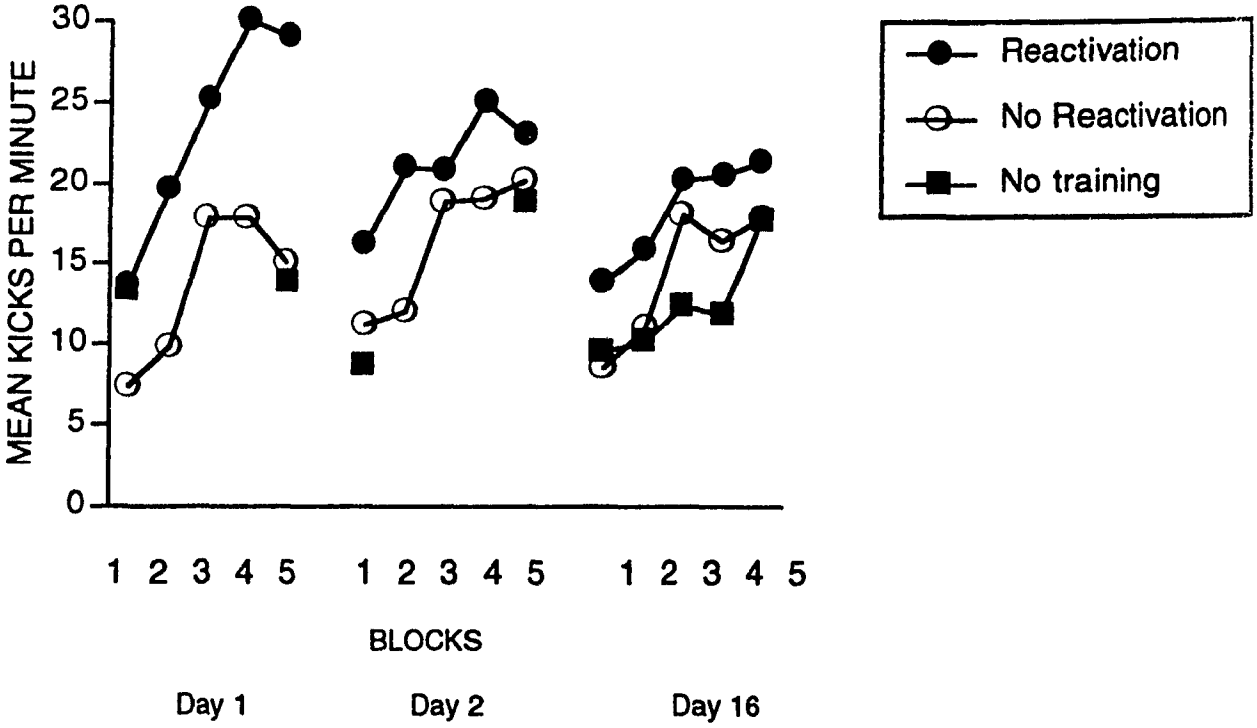


FIGURE 1. Experiment 1 mean kicks per minute during baseline (block 1), reinforcement (blocks 2-4), and extinction (block 5) phases.

considerable variability in the kick rate of the reactivation and no reactivation groups across training days. The difference in variability was, however, not significant. The results of Levene's test of homogeneity of variance are found in Appendix D.

Operant Acquisition. To ensure that the groups did not differ prior to training, the reactivation, no reactivation, and no training control groups' pretraining levels of kicking were compared. A Group (3) x Minute (3) ANOVA was conducted on the initial 3 minutes of the first visit. No significant group differences emerged. There was, however, a significant effect of Minutes, $F(2,54) = 4.26$, $p<.025$, with less kicking occurring in the first of the three minutes. The mean number of kicks across groups was 8.1 for minute 1, 13.1 for minute 2, and 13.0 for minute 3. Paired comparisons using the Tukey test indicated that minute 1 was significantly different from minutes 2 and 3, $p < .05$, and minutes 2 and 3 were not significantly different from each other.

The Day 1 and 2 performance of the reactivation and no reactivation group was then contrasted to verify that the groups responded similarly in the acquisition phase of the experiment. Nine infants in both the reactivation and the no reactivation control groups were found to have acquired the contingency within the first training session (Day 1) by meeting the learning criterion of kicking 1.5 times their baseline level in 2 of 3 consecutive minutes. Group performance was also shown to be similar across training sessions. A Group (2) x Day (2) x Block (5) ANOVA on the footkick data indicated that there was no significant effect of Group or Day and no significant interactions. There was, however, a significant effect of block with infants in both the reactivation group and the no reactivation control group showing increased kicking across blocks, $F(4, 72) = 10.64$, $p<.001$. A Tukey test showed that infants kicked significantly more in blocks 3, 4, and 5 than in block 1, $p<.01$.

The kick rate of the no training control group was then analyzed across Days 1 and 2 to ensure that viewing the motionless mobile did not influence infants' rate of

kicking. A significant Day (2) x Block (2) interaction, $F(1,9) = 11.32$, $p<.01$, was obtained. A test of simple effects revealed a significant difference across blocks of Day 2, $F(1, 9) = 8.99$, $p < .025$, with infants kicking more during block 5 than block 1. This relationship can be seen in Figure 2.

Additional group comparisons were done on 24-hour baseline and retention ratios (Davis & Rovee-Collier, 1983). The 24-hour baseline ratio, which is a measure of memory over 24 hours, was obtained by dividing infants' mean kicks in Block 1 of Day 2 by their pretraining level of kicking, or Block 1 of Day 1. The 24-hour retention ratio, also considered a measure of memory, was calculated by dividing infants' mean kicks in Block 1 of Day 2 by their mean kicks in Block 5 of Day 1. The mean 24-hour baseline and retention ratios are found in Table 3. One-way ANOVAs indicated no significant group differences on either the baseline or the retention ratio. ANOVA summary tables are found in Appendix D.

24-Hour Retention. To test for recall over 24 hours, directional t-tests were calculated comparing the 24-hour baseline and retention ratios of the three groups to a theoretical value of 1.0. A baseline ratio that is significantly greater than 1.0 is thought to reflect memory because infants are kicking above their pretraining level. Similarly, a retention ratio that approaches a value of 1.0 suggests retention because infants begin kicking at the same rate as that produced at the end of the previous day. For the retention ratio to be a meaningful index of memory, however, infants must first have met the learning criterion (Davis & Rovee-Collier, 1983). According to Rovee-Collier, Earley, and Stafford (1989), a baseline ratio that is significantly greater than 1.0, together with a retention ratio that approaches a value of 1.0 is said to provide evidence of "perfect" recall. This is contrasted with "intermediate" recall which is obtained when the baseline ratio is significantly greater than 1.0, but the retention ratio is significantly less than 1.0. If the baseline ratio is not significantly greater than 1.0,

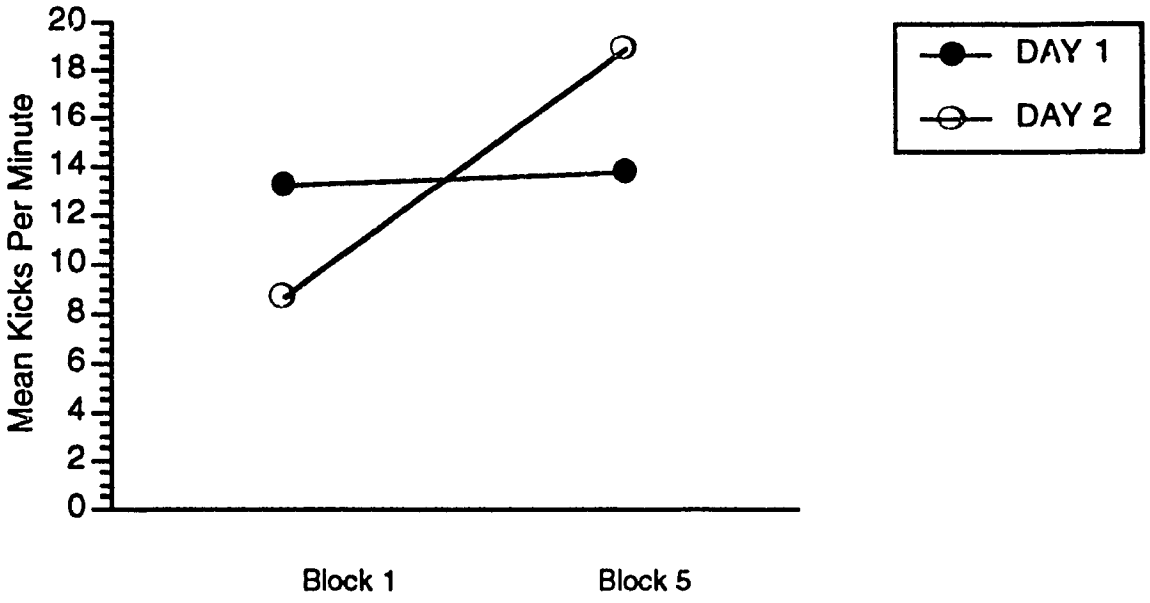


FIGURE 2. Experiment 1 Day X Block interaction in the No Training group kick rate.

infants are said to have shown no retention regardless of their performance on the retention ratio (Rovee-Collier & Dufault, 1991). Of the three groups, only the no reactivation group showed evidence of retention after 24 hours with a baseline ratio that was significantly greater than 1.0, $t(9) = 2.87$, $p<.01$, and a retention ratio that did not differ significantly from 1.0. The baseline ratios of the reactivation and no training control groups were not significantly greater than 1.0. The no training control group's baseline ratio was in fact, significantly less than 1.0, $t(9) = 1.89$, $p < .05$. The retention ratios of the reactivation and no training groups were not significantly different from 1.0 (see Appendix D).

Individual baseline and retention ratios were then inspected to see how many infants in each group showed evidence of perfect or intermediate recall. If only those infants who met the learning criterion by the end of Day 1 and whose 24-hour baseline ratio was 1.5 or more are considered, 5 infants (4 perfect, 1 intermediate) in the reactivation group and 4 infants (2 perfect, 2 intermediate) in the no reactivation group showed evidence of recall over 24 hours.

To see whether infants showed evidence of recognition memory, a 24-hours savings ratio was computed. This ratio is obtained by adding the kicks in blocks 2 through 4 of Day 1 (C); repeating the procedure for Day 2 (D); then subtracting the value for Day 1 from that of Day 2 (D-C), and dividing it by the Day 1 value (VanderLinde, Morrongiello, & Rovee-Collier, 1985). A positive savings ratio is thought to provide evidence of memory since there is a greater amount of kicking on Day 2 than on Day 1. The mean 24-hour savings ratio for the reactivation and no reactivation group are found in Table 3. Neither group's savings ratio was found to be significantly different from 0.

Day 16 Longterm Memory Test. To test for an effect of the different treatment conditions, longterm memory performance of all three groups was compared on Day 16.

Table 3

24-Hour and 2-Week Baseline, Retention, and Savings Ratios

| | Baseline | Retention | Savings |
|---|---|---|---|
| | 24-HR / 2-WK | 24-HR / 2-WK | 24-HR / 2-WK |
| **Groups** | | | |
| **Reactivation** | | | |
| Mean | 1.7 / 1.3 | 0.9 / 0.7*** | 0.0 / -0.1 |
| S.D. | 1.6 / 0.9 | 0.6 / 0.3 | 0.4 / 0.4 |
| Range | 0.2-4.7 / 0.3-3.5 | 0.1-1.9 / 0.1-1.2 | -0.7-0.7 / -0.5-0.9 |
| **No Reactivation** | | | |
| Mean | 1.8** / 1.7 | 0.8 / 0.5*** | 0.0 / 0.2 |
| S.D. | 0.9 / 1.5 | 0.5 / 0.4 | 0.4 / 0.5 |
| Range | 0.9-3.8 / 0.1-4.6 | 0.3-1.9 / 0.0-1.3 | -0.6-0.6 / -0.6-1.0 |
| **No Training** | | | |
| Mean | 0.8* / 0.8 | 1.1 / 0.6* | - |
| S.D. | 0.4 / 0.6 | 0.9 / 0.6 | - |
| Range | 0.1-1.6 / 0.2-2.0 | 0.1-2.5 / 0.1-1.9 | - |

* $p < .05$. ** $p < .025$. *** $p < .01$.

The first analysis, a Group (3) x Block (5) ANOVA revealed no significant differences in mean kick rate across groups. There was, however, a significant effect of Block with infants in all groups showing increased kicking across blocks, $F(4, 108) = 7.08$, $p < .001$. A Tukey test indicated that infants kicked significantly more in blocks 3, 4, and 5 than in block 1, $p < .05$. Two other analyses compared the 2-week baseline and retention ratios of the three groups. The 2-week baseline ratio was obtained by dividing Block 1, Day 16 mean footkicks by Block 1, Day 1 mean footkicks. The 2-week retention ratio was calculated by dividing Block 1, Day 16 mean footkicks by Block 5, Day 2 mean footkicks (Davis & Rovee-Collier, 1983). One-way ANOVAs revealed no significant group differences for either the 2-week baseline or retention ratios. (see Appendix E)

Next, to test for memory within each group, the 2-week baseline and retention ratios were compared to the theoretical value of 1.0 (refer to Table 3) using directional t-tests. The analyses revealed no evidence of longterm retention for any of the groups. On the contrary, there was evidence of significant forgetting. The baseline ratios were not significantly greater than 1.0, and the 2-week retention ratios of the no reactivation, reactivation, and no training control groups were significantly less than 1.0, with $t(9) = 4.0$, $p < .01$ for the reactivation group, $t(9) = 4.4$, $p < .01$ for the no reactivation group, and $t(9) = 2.1$, $p < .05$ for the no training control group. (see Appendix E)

When individual baseline and retention ratios were inspected 4 of the 10 infants in the no reactivation group and 3 of the 10 infants in the reactivation group showed evidence of "perfect" recall with a baseline ratio that was 1.5 or higher and a retention ratio of 0.60 or better. No infants showed evidence of intermediate recall.

The 2-week savings ratio was then calculated for both the reactivation and the no reactivation group to see whether infants showed evidence of recognition memory. The

ratio is obtained by adding the kicks in blocks 2 through 4 of Day 1 (C); repeating the procedure for Day 16 (D); then subtracting the value for Day 1 from that of Day 16 (D-C), and dividing it by the Day 1 value (VanderLinde, Morrongiello, & Rovee-Collier, 1985). The mean 2-week savings ratio for the reactivation and no reactivation group are found in Table 3. Directional t-tests indicated that neither group's savings ratio was significantly different from 0. Of those who showed evidence of recall at 2 weeks, only 2 infants in the no reactivation group had a substantial (more than 0.60) positive savings ratio.

Comparison of First Training Session. The performance of the no training group on Day 16 was compared to the Day 1 performance of the reactivation and no reactivation group to verify that its response on the first training session (Day 16) was like that of the other two groups on their first training session (Day 1) and that its ability to learn the contingency had not been affected by prior exposure to the motionless mobile. The number of infants in the no training control group to reach the learning criterion of 1.5 times the baseline value in the first training session on Day 16 was 7. This was similar to the performance of infants in the reactivation (N = 9) and no reactivation (N = 9) groups on Day 1. A Group (3) X Block (5) ANOVA was then calculated. A significant Block effect, $F(4, 108) = 11.1$, $p < .001$, was found with kicking in blocks 3, 4, and 5 being significantly greater than that in block 1, $p < .05$. The Group effect approached significance, $F(2, 27) = 3.22$, $p < .06$. Tukey tests revealed that the Group effect was attributable to the fact that the rate of kicking of the reactivation group across blocks was greater than that of the other two groups, $p < .05$. Figure 3 shows the first training day for all three groups.

Visual Attention Data. To verify that infants' footkick performance was not due to inattention, the time infants spent looking at the mobile was calculated for each group. Table 4 shows the mean seconds per minute each group spent looking at the mobile in the

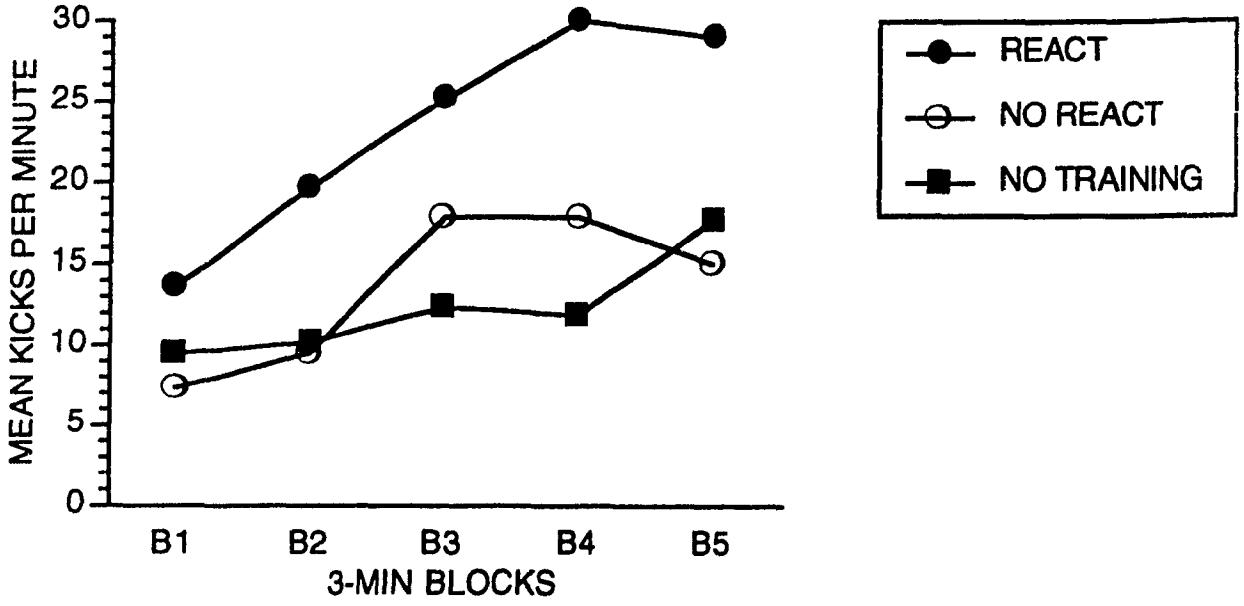


FIGURE 3. Experiment 1 mean kicks per minute across blocks of the first training day for the reactivation (Day 1), no reactivation (Day 1), and no training (Day 16) groups.

Table 4

Mean Visual Attention Scores (seconds per minute) For All Phases of Each Day

| | Day 1 | | | Day 2 | | | Day15 | Day16 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Phase[a] | | | Phase[a] | | | Phase[a] | Phase[a] | | |
| | B | R | E | B | R | E | P | B | R | E |
| No Reactivation | | | | | | | | | | |
| Mean | 51 | 54 | 39 | 39 | 54 | 49 | - - | 51 | 52 | 48 |
| S.D. | 9 | 8 | 17 | 22 | 11 | 17 | | 11 | 12 | 18 |
| Reactivation | | | | | | | | | | |
| Mean | 48 | 55 | 50 | 55 | 56 | 49 | 4 6 | 49 | 56 | 38 |
| S.D. | 16 | 7 | 16 | 5 | 8 | 20 | 1 2 | 10 | 5 | 19 |
| No Training | | | | | | | | | | |
| Mean | 46 | -- | 47 | 51 | -- | 52 | 4 6 | 48 | 53 | 38 |
| S.D. | 1 8 | | 12 | 1 0 | | 11 | 1 5 | 16 | 9 | 23 |

[a] B Baseline Phase

R Reinforcement Phase

E Extinction Phase

P Reactivation

baseline, reinforcement, extinction, and reactivation phases of testing. The reactivation and no reactivation groups' visual attention across Days 1 and 2 was then compared to ensure that these groups did not differ on the time they spent looking at the mobile during the acquisition phase. A Group (2) x Day (2) x Phase (3) ANOVA revealed a significant effect of phase, $F(2, 36) = 6.05$, $p < .01$, and a significant triple interaction, $F(2, 36) = 3.83$, $p < .05$ (see Figure 4). The phase effect indicated that infants spent more time looking at the mobile during the reinforcement phase than during either the baseline or the extinction phase, $p < .05$, but the triple interaction reflected the fact that certain phase differences were more marked in the no reactivation group. There was a marked decrease in visual attention by the no reactivation group during Day 1 extinction which was maintained on Day 2 baseline, whereas the reactivation group showed little decrease in attention in extinction on Day 1 and returned to reinforcement levels of attention on Day 2 baseline. The no training group's visual attention across Days 1 and 2 was also analysed in a Day (2) x Phase (2) ANOVA. This was done to ensure that this group's level of attention remained the same throughout Day 1 and 2. No significant day or phase effects were found.

The Day 15 mean visual attention of the reactivation and no training groups was also compared to verify that there were no significant group differences in attention to the mobile during the reactivation treatment. A One-Way ANOVA showed no significant group differences in visual attention. Finally, the Day 16 visual attention data of the reactivation, no reactivation, and no training control groups were compared (see Figure 5). A Group (3) x Phase (3) ANOVA revealed no significant group effect. There was a significant effect of phase, $F(2, 54) = 9.26$, $p < .001$, however, with infants spending more time looking at the mobile in the reinforcement phase than in the extinction phase, $p < .01$, and less time in the extinction phase than in the baseline phase, $p < .05$. The visual attention ANOVA source tables are found in Appendix F.

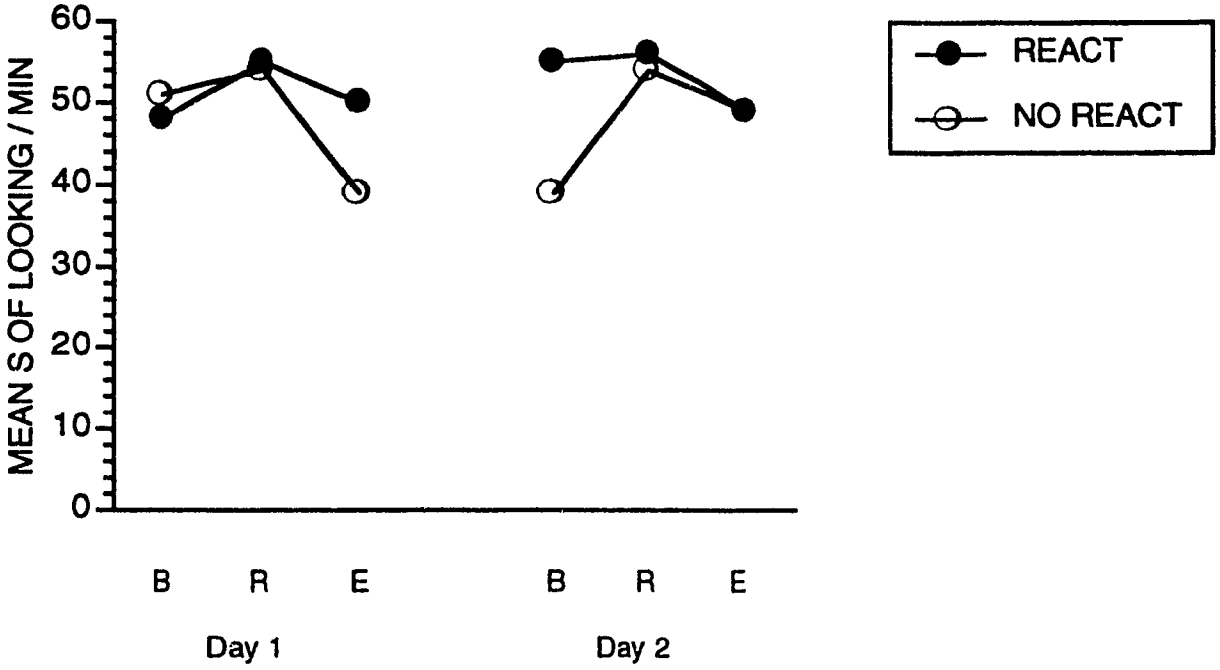


FIGURE 4. Experiment 1 Group X Day X Phase interaction in visual attention by the Reactivation and No Reactivation groups.

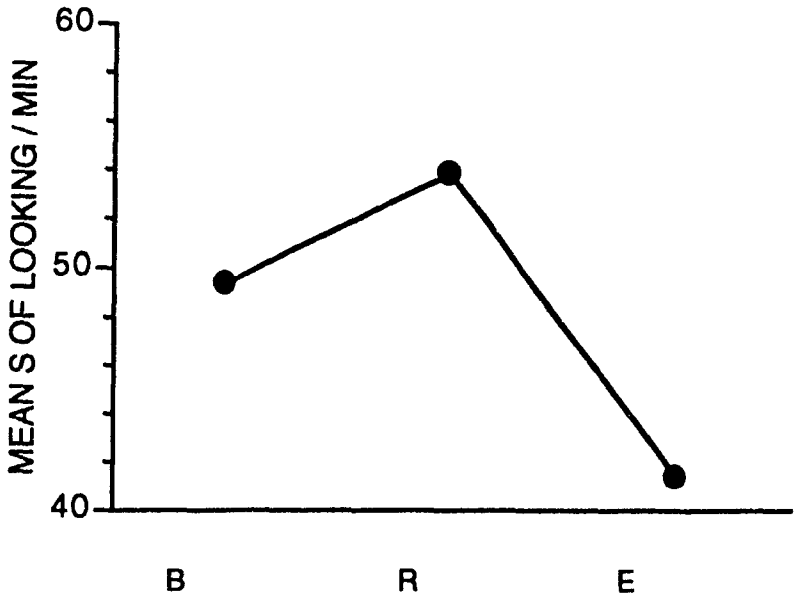


Figure 5. Experiment 1 Day 16 Phase effect collapsed over groups (Reactivation, No Reactivation, and No Training).

Discussion

The purpose of the first study was to replicate Sullivan's finding that 3-month-old fullterm infants who are given two 15-minute training sessions can learn to kick to make a mobile move, and can remember the contingency 2 weeks after having learned only with the help of a reactivation treatment. The results of this study provide only partial replication of Sullivan's findings in that infants were able to learn to kick to make a mobile move, and some (50%) of those who learned the operant on Day 1 showed strong evidence of recall (baseline ratio of 1.5 or more) over 24 hours. There was no evidence, however, that infants who were given a reactivation treatment did better on a longterm memory test than others not given the treatment.

With respect to acquisition, the reactivation and no reactivation groups response was like that of equivalent groups in previous studies (Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980; Rovee-Collier, Enright, Lucas, Fagen, & Gekoski, 1981; Sullivan, 1982; Rovee-Collier, 1983). Both groups responded similarly and showed evidence of having acquired the operant. More specifically, most (90%) of the infants reached the learning criterion by the end of the first training session and showed significant increases in kicking across blocks of Days 1 and 2.

Although the footkick data during the training phase indicated that the reactivation and no reactivation groups did not differ, the visual attention data suggested otherwise. The no reactivation group spent less time looking at the mobile on Day 1 extinction and Day 2 baseline than the reactivation group. A decrease in visual attention to the mobile during the nonreinforcement phases of training by 3-month-old fullterm infants has been reported by Rovee-Collier (1984) who suggested that by shifting their gaze away from the mobile, infants were encoding additional information which might help them with memory. The superior performance of the no reactivation group on

retention at 24 hours is consistent with this explanation of their visual attention performance.

On the longterm memory test, the no reactivation group failed to recall the operant. This is consistent with Sullivan's (1982) findings which show that without a reactivation treatment, 3-month-old fullterm infants are unable to recall the operant on a 2-week longterm memory test. Unlike previous findings however, the reactivation group who received a reactivation treatment also showed no evidence of longterm retention. Instead, there was evidence of significant forgetting. In a personal communication (June, 1987), C. Rovee-Collier suggested that infants in the reactivation group did not remember the contingency over 2 weeks because the reactivation treatment had not been effective. By placing the infant's own mobile in the crib following the reactivation treatment, infants whose first retrieved memories of the task are not mobile specific, might mistake their own mobile for that of the test mobile and kick to make their mobile move. When their mobile did not respond to the kick, their kicking behavior would extinguish. Consequently no evidence of memory would be found during the longterm retention test. This explanation might account for the reactivation group's performance on Day 16 since all infants had access to their own mobiles after the reactivation treatment.

Finally, the performance of infants in the no training control group was perplexing. Their different response across Days 1 and 2 suggests that exposure to the motionless mobile may have affected them. Possibly infants in this group might have made the mobile move by jiggling the crib when they kicked, because the hook from which the mobile hung was connected to the side of the crib and movement of the crib did produce a slight movement of the mobile. The results of Experiment 1 indicated a need for more stringent control over test environment and procedures. Therefore before proceeding to the main study of preterm infants, a second attempt was made to replicate

the reactivation effect in fullterm infants. Procedural changes were incorporated to the second experiment to provide a more uniform and distinctive learning environment.

## Experiment 2

The purpose of Experiment 2 was to replicate the reactivation effect in 3-month-old fullterm infants using a modified procedure. To control for mobile movement during the nonreinforcement phases, the hook which held the mobile was suspended from a drumboom rather than the side of the crib. Moreover the infant was not allowed to see his/her own mobile between the reactivation phase of treatment and the longterm memory test. A bright yellow crib bumper was placed in the infant's crib throughout testing. This was done to standardize the learning environment, and make it more distinctive thus providing an additional cue to facilitate retrieval of the memory (Rovee-Collier, Griesler, & Earley, 1985).

### Method

Subjects. Twenty-four 3-month-old fullterm infants born between June, 1988 and December, 1989 were recruited through birth announcements in the same manner as in Experiment 1. They were randomly assigned to one of three treatment conditions: a reactivation, no reactivation, or no training control condition. Each group consisted of 4 male and 4 female caucasian infants. Seven infants in both the no reactivation and no training control group, and 5 infants in the reactivation group were delivered vaginally. The other 5 infants were delivered by C-Section (3 repeat and 2 CPD). One or both parents of all infants were born in Canada. Infants were predominantly from middle class English speaking families. An additional 9 infants, 6 from the no reactivation group, 1 from the reactivation group, and 2 from the no training control group were lost due to excessive crying (N = 5), inability to meet the learning criterion (N = 2), turning over (N = 1), and procedural error (N = 1). This 27% subject loss is similar to that obtained in the first study.

The criteria for inclusion of infants in this study were identical to that of Study 1. Infant and parental characteristics are found in Tables 5 and 6, respectively. Analyses of variance revealed no significant group differences on any of the infant or parental characteristics. (see Appendix B )

Apparatus. In addition to the equipment described in Study 1, a 60cm high bright yellow crib bumper was used to line the infant's crib and a Camber drumboom, model 1156 was used as a stand for the mobile.

Procedure. The procedure in this study was like that of Study 1 except that a yellow crib bumper was placed in the infant's crib in all sessions, the hook from which the mobile was suspended was attached to a floor stand (the drumboom) rather than connected to the side of the crib, and after receiving the reactivation treatment on Day 15, mothers of infants in the reactivation and no training control groups were asked to keep their child's mobile out of the infant's view until after the completion of the longterm memory test on Day 16.

As in the previous study, footkicks and visual attention were scored from videotapes by a trained rater blind to the experimental hypotheses, the infants' group membership, and the session being viewed. Rater reliability obtained in the same manner as in Experiment 1, for 100% of the footkick data and 20% of the visual attention data, was .83 for the footkick data and .94 for the visual attention data. All analyses were computed using the blind rater's data.

Table 5

Infant Characteristics

| | Group | | |
|---|---|---|---|
| | No Reactivation | Reactivation | No Training |
| Birthweight (grams) | | | |
| Mean | 3424.0 | 3504.1 | 3701.6 |
| S.D. | 320.4 | 287.4 | 292.5 |
| Range | 2920-3755 | 3033-3856 | 3402-4167 |
| GA (weeks/days) | | | |
| Mean | 39/4 | 39/6 | 39/5 |
| S.D. | 0/6 | 0/6 | 0/4 |
| Range | 38/1-41/6 | 38/4-40/6 | 39/1-40/3 |
| Apgar 1-min (5-min) | | | |
| Mean | 8.3 (9.0) | 8.0 (8.9) | 8.2 (9.4) |
| S.D. | 0.8 (0.6) | 0.8 (0.4) | 0.7 (0.5) |
| Range | 7-9 (8-10) | 7-9 (8-9) | 7-9 (9-10) |
| Chronological Age on Day 1 (weeks/days) | | | |
| Mean | 13/1 | 13/1 | 13/2 |
| S.D. | 1/1 | 0/6 | 0/5 |
| Range | 10/3-14/1 | 11/4-14/0 | 12/2-14/6 |
| Corrected Age on Day 1 (weeks/days) | | | |
| Mean | 12/6 | 13/1 | 13/1 |
| S.D. | 0/5 | 0/6 | 0/5 |
| Range | 12/1-14/0 | 12/0-14/4 | 12/0-14/0 |

Table 6

Parental Characteristics

| | Group | | |
|---|---|---|---|
| | No Reactivation | Reactivation | No training |
| Maternal Age (yrs) | | | |
| Mean | 30.5 | 30.4 | 30.7 |
| S.D. | 4.7 | 3.5 | 6.4 |
| Range | 24-38 | 25-37 | 25-39 |
| Paternal Age (yrs) | | | |
| Mean | 32.7 | 31.5 | 34.2 |
| S.D. | 3.8 | 4.4 | 5.5 |
| Range | 27-38 | 26-37 | 27-41 |
| Maternal Education (yrs) | | | |
| Mean | 15.7 | 15.4 | 17.1 |
| S.D. | 3.0 | 2.8 | 3.5 |
| Range | 12-21 | 12-20 | 12-21 |
| Paternal Education (yrs) | | | |
| Mean | 15.6 | 15.1 | 18.2 |
| S.D. | 2.5 | 5.0 | 3.1 |
| Range | 11-19 | 8-23 | 14-21 |
| Hollingshead Index of Social Position | | | |
| Mean | 2.4 | 2.2 | 1.4 |
| S.D. | 1.3 | 0.9 | 0.7 |
| Range | 1-4 | 1-4 | 1-3 |

## Results

Operant Acquisition. The Day 1, 2, and 16 mean footkick data of the reactivation, no reactivation, and no training groups are found in Appendix G and are shown in Figure 6. The three groups' pretraining levels of kicking were compared to verify that they were similar across groups prior to treatment by a Group (3) x Minutes (3) ANOVA. No significant Group or Minute effect was found. The same number of infants in the reactivation and no reactivation groups (7) reached the learning criterion of kicking 1.5 times their baseline level on the first training day. The remaining infants met the learning criterion on Day 2. A Group (2) X Day (2) X Block (5) ANOVA revealed significant Day, $F(1, 14) = 6.1$, $p < .05$, and Block, $F(4, 56) = 5.7$, $p < .001$, effects. Infants produced considerably more kicking on Day 2 than on Day 1, and their kicking increased across blocks on each day. A Day (2) X Block (2) ANOVA of the data for the no training group revealed no significant Day or Block effect. Thus, the no training group's level of kicking remained the same across blocks 1 and 5 of Days 1 and 2.

Additional group comparisons were made involving the groups' 24-hour baseline and retention ratios (see Table 7). One-way ANOVAs revealed no significant group differences on either the baseline or retention ratios.

24-Hour Retention. To test for recall, each group's 24-hour baseline and retention ratios were compared to the theoretical value of 1.0 using directional t-tests. The 24-hour baseline ratio was not found to be significantly greater than 1.0. The reactivation and no training groups' retention ratios were not significantly different from 1.0, whereas the no reactivation group's retention ratio was significantly less than 1.0, $t(7) = 2.56$, $p < .025$. If one considered only those infants who acquired the operant by the end of Day 1, 4 out of 7 infants in the no reactivation group and 3 out of 7 infants in the reactivation group had a baseline ratio of 1.5 or more and remembered the operant over 24 hours.

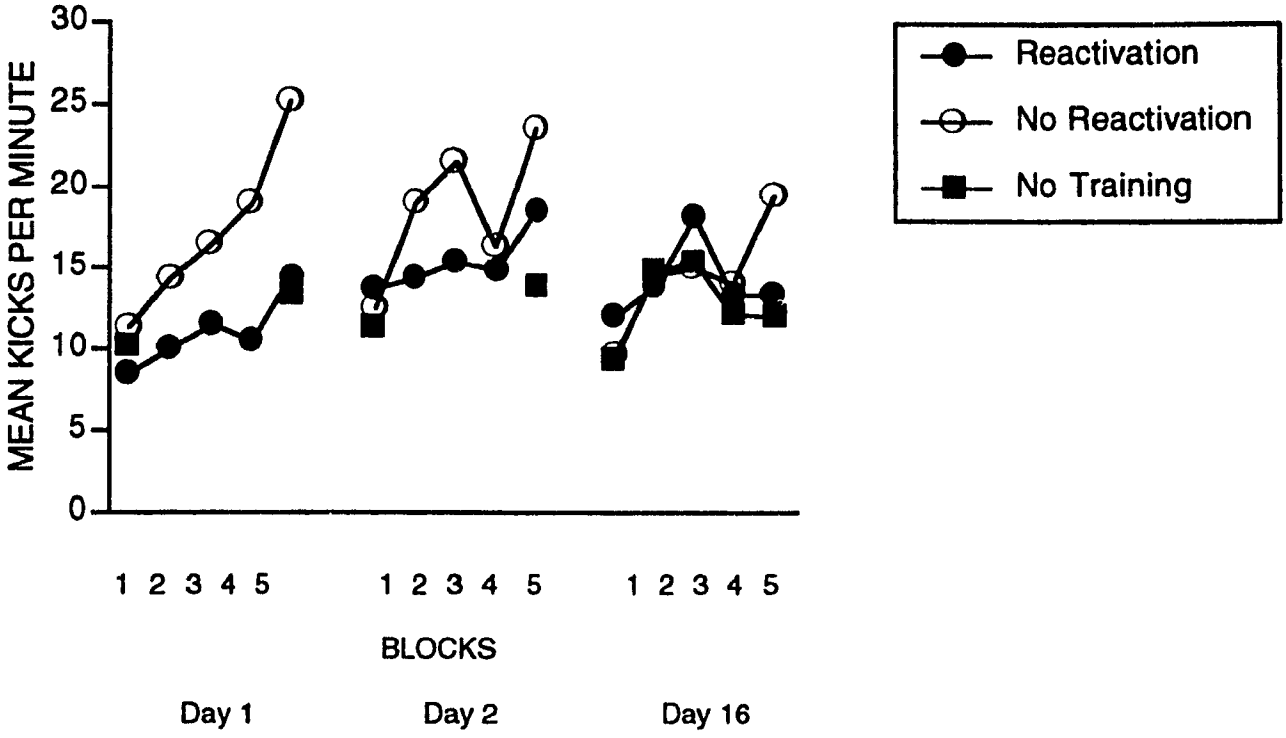


FIGURE 6. Experiment 2 mean kicks per minute during baseline (block 1), reinforcement (blocks 2-4), and extinction (block 5) phases.

Table 7

Mean 24-Hour and 2-Week Baseline, Retention, and Savings Ratios

| | Baseline | Retention | Savings |
|---|---|---|---|
| | 24-HR / 2-WK | 24-HR / 2-WK | 24-HR / 2-WK |
| **Groups** | | | |
| **Reactivation** | | | |
| Mean | 3.1 / 1.8* | 0.9 / 0.9 | 0.3** / 0.5 |
| S.D. | 5.8 / 1.0 | 0.6 / 0.7 | 0.2 / 0.8 |
| Range | 0.6-17.5 / 0.7-3.8 | 0.4-2.2 / 0.3-2.3 | 0.0-0.7 / -0.6-1.9 |
| **No Reactivation** | | | |
| Mean | 1.6 / 1.1 | 0.6* / 0.4*** | 0.2 / 0.0 |
| S.D. | 1.3 / 1.3 | 0.4 / 0.3 | 0.4 / 0.4 |
| Range | 0.2-4.4 / 0.2-4.3 | 0.1-1.4 / 0.1-0.8 | -0.3-1.0 / -0.5-0.6 |
| **No Training** | | | |
| Mean | 1.1 / 1.1 | 1.0 / 0.7 | - |
| S.D. | 0.4 / 0.9 | 0.7 / 0.6 | - |
| Range | 0.4-1.6 / 0.4-3.1 | 0.3-2.4 / 0.1-1.9 | - |

* $p < .05$. ** $p < .01$. *** $p < .001$.

To investigate whether there was evidence of 24-hour recognition memory, the reactivation and no reactivation groups' savings ratio were compared to the theoretical value of 0. Only the reactivation group's savings ratio was significantly different from 0, $t(7) = 3.95$, $p < .005$.

Day 16 Longterm Memory Test. A Group (3) X Block (5) ANOVA of the footkick data revealed a significant effect of Block, $F(4, 84) = 3.2$, $p < .05$, with infants showing significantly more kicking on block 3 than block 1, $p < .05$. There were no significant effect of Group and no significant Group X Block interaction. The three groups' baseline and retention ratios (see Table 7) were then compared. One-way ANOVAs revealed no significant group differences on either the 2-week baseline or retention ratio.

To test for longterm memory, each group's 2-week baseline and retention ratios were compared to the theoretical value of 1.0 using directional t-tests. The reactivation group's 2-week baseline ratio was significantly greater than the theoretical value of 1.0, $t(7) = 2.2$, $p < .05$, and its 2-week retention ratio was not significantly different from 1.0, thus showing evidence of retention. In contrast the no reactivation group's baseline ratio was not significantly different from 1.0, and its retention ratio was significantly less than 1.0, $t(7) = 6.02$, $p < .001$. The no training group's 2-week baseline and retention ratios were not significantly different than 1.0.

When individual baseline and retention ratios were inspected, 4 of the 8 infants in the reactivation group had a baseline ratio that exceeded 1.50 and 3 of these 4 infants also had a 2-week retention ratio that was greater than 0.80. In comparison, only 1 of the 8 infants in the no reactivation group had a baseline ratio that exceeded 1.50.

The reactivation and no reactivation groups' 2-week savings ratio were compared to the theoretical value of 0. Neither groups' savings ratio was significantly different from 0.

Finally, the no training control group's performance on Day 16 was compared to that of the reactivation and no reactivation groups on Day 1. Like infants in the latter two groups, 7 out of 8 infants in the no training control group learned the contingency within one training session. A Group (3) x Blocks (5) ANOVA was computed. No significant Group effect was found. There was, however, a significant effect of Block, $F(4, 84) = 6.9$, $p < .001$, and a significant Group X Block interaction. $F(4, 84) = 2.56$, $p < .01$. The interaction, which is depicted in Figure 7, shows the reactivation and no training control groups' kicking on blocks 4 and 5 to be lower than that of the no reactivation group.

Visual Attention. The mean visual attention per minute to the mobile during the baseline, reinforcement, extinction, and reactivation phases of testing for each group are reported in Table 8. To insure that the reactivation and no reactivation groups' visual attention did not differ in the training phase (Day 1 and Day 2), a Group (2) x Day (2) x Phase (3) ANOVA was done. The analysis revealed no significant Group or Day effect and no significant interactions. There was, however, a significant effect of Phase, $F(2, 28) = 4.6$, $p < .025$. As shown in Figure 8, infants spent significantly more time looking at the mobile when it was in motion than when it was motionless, $p < .05$. Visual attention of the no training group during the baseline and extinction phases of Days 1 and 2 was also submitted to an ANOVA to check that the amount of time infants spent looking at the mobile in the training phase remained constant. No significant effect of Day or Phase was found.

The reactivation and no training groups' visual attention during the reactivation treatment was compared by means of a one-way ANOVA and no significant difference was found. An ANOVA was then computed on the three groups' visual attention during the three phases of the Day 16 longterm memory test. The only significant effect was that of Phase, $F(2, 42) = 15.2$, $p < .001$, with infants spending more time looking at the

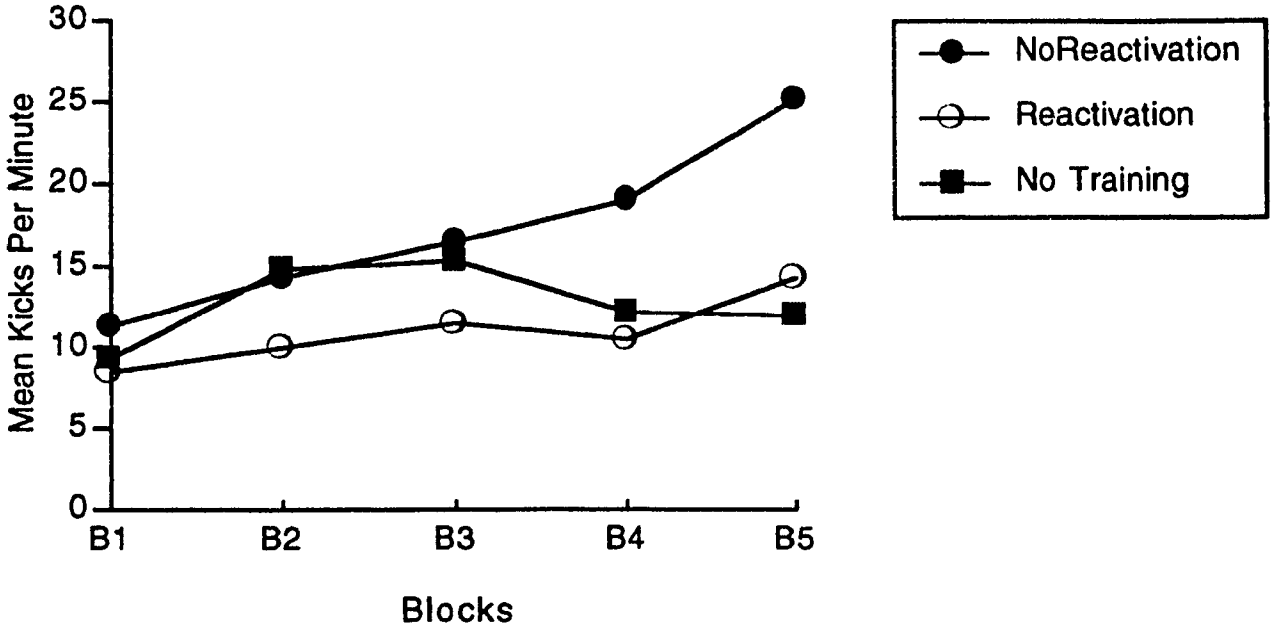


FIGURE 7. Experiment 2 Group X Block Interaction in the first training session footkick data for the Reactivation (Day 1), No Reactivation (Day 1), and No Training (Day 16) groups.

Table 8

Mean Visual Attention Scores (seconds per minute) For All Phases of Each Day

| | Day 1 | | | Day 2 | | | Day15 | Day16 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Phase[a] | | | Phase[a] | | | Phase[a] | Phase[a] | | |
| | B | R | E | B | R | E | P | B | R | E |
| No Reactivation Group | | | | | | | | | | |
| Mean | 57 | 60 | 56 | 51 | 56 | 55 | -- | 53 | 56 | 46 |
| S.D. | 3 | 0.4 | 4 | 11 | 4 | 7 | | 7 | 5 | 12 |
| Reactivation Group | | | | | | | | | | |
| Mean | 52 | 58 | 54 | 53 | 59 | 49 | 56 | 56 | 58 | 42 |
| S.D | 10 | 3 | 7 | 11 | 2 | 17 | 8 | 5 | 4 | 18 |
| No Training Group | | | | | | | | | | |
| Mean | 55 | -- | 54 | 54 | -- | 57 | 46 | 58 | 58 | 53 |
| S.D. | 10 | | 9 | 8 | | 5 | 20 | 2 | 3 | 9 |

[a] B Baseline Phase

R Reinforcement Phase

E Extinction Phase

P Reactivation

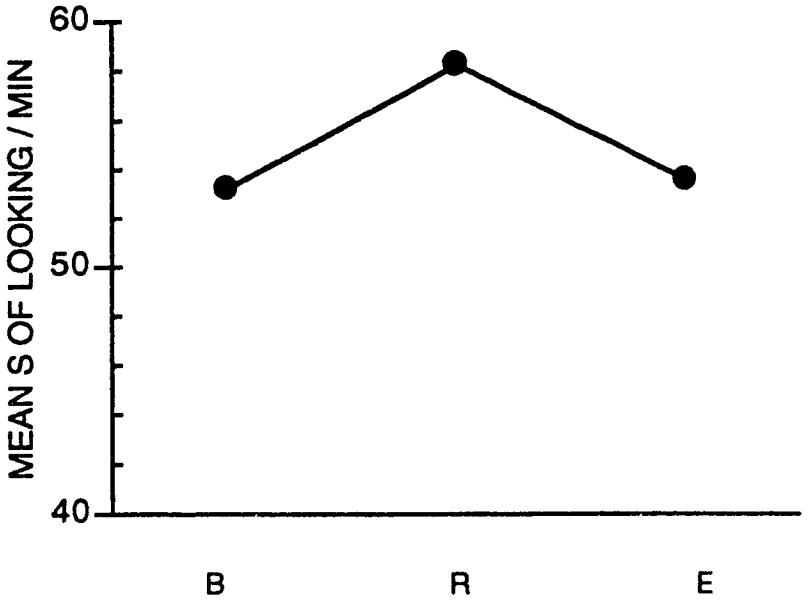


FIGURE 8. Experiment 2 Phase effect collapsed over groups (Reactivation and No Reactivation) and days (Day 1-2).

mobile in the baseline and reinforcement phases than in the extinction phase, $p < .05$ (see Figure 9). The ANOVA source tables for the visual attention data are found in Appendix I.

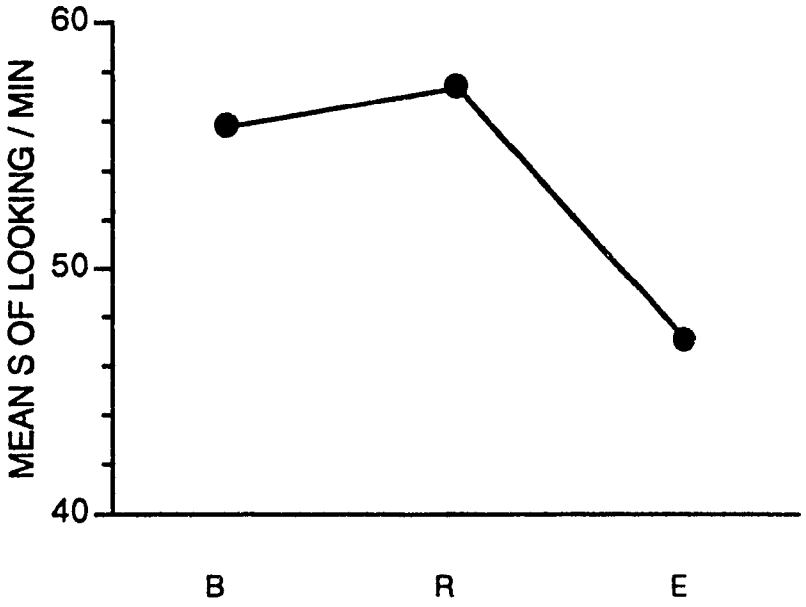


FIGURE 9. Experiment 2 Day 16 Visual Attention Phase effect collapsed over groups (Reactivation, No Reactivation, and No Training).

Discussion

The purpose of Experiment 2 was to replicate the reactivation effect after modifying the procedure used in Experiment 1. The results of Experiment 2 are consistent with Sullivan's (1982) and previous findings (Rovee-Collier, 1983; Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980; Rovee-Collier, Enright, Lucas, Fagen, & Gekoski, 1981) . Infants in the reactivation and no reactivation group responded similarly during the acquisition phase. They both showed evidence of having acquired the operant by increasing their kick rate across blocks of the two training days. The same number of infants in each group met the learning criterion by Day 1. The remaining infants met the learning criterion by the end of Day 2. There were no significant group differences on visual attention across training days. Both groups spent more time looking at the mobile when it was moving than when it was motionless.

The kick rate of infants in the no training group remained the same across blocks of Days 1 and 2. This finding is like that reported in previous studies (Sullivan, 1982; Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980) and is said to suggest that exposure to the motionless mobile does not in and of itself result in increase kicking. The difference in kick rate across blocks of Day 2 observed in Study 1 was not seen in Study 2. The lack of increase in kicking across blocks of Days 1 and 2 by the no training group in this study is most likely due the change in procedure which made it impossible for infants to make the mobile move by jiggling the crib.

With respect to memory over 24 hours, the reactivation and no reactivation groups both showed some evidence of recognition memory. Infants in these groups kicked more in the reinforcement phase of Day 2 than of Day 1. There was little or no evidence of 24-hour recall by either group as a whole. Evidence of recall was found only when the responses of individual infants were considered. If one considers only those infants who learned the operant on Day 1, 4 out of 7 infants in the no reactivation group and 3

out of 7 infants in the reactivation group had a 24-hour baseline ratio that exceeded 1.5 and a retention ratio that was close to 1.0.

Although the reactivation and no reactivation groups did not differ in the training phase of Days 1 and 2, they did differ on measures of recall and recognition memory at 2 weeks. Only the reactivation group showed evidence of recall and recognition memory with a baseline ratio that was significantly greater than 1.0, a retention ratio that did not differ significantly from 1.0, and a strong positive savings ratio. Infants in this group kicked significantly more during the initial 3 minutes of Day 16 than during the pretraining level of Day 1, and their performance in the initial phase of Day 16 did not differ significantly from their level of kicking in the last 3 minutes of Day 2. They also showed more kicking in the reinforcement phase of Day 16 than that of Day 1. On an individual basis, 4 of the 8 infants showed evidence of perfect or intermediate retention with a baseline ratio that exceeded 1.50 and a retention ratio of .80 or greater. In contrast, the no reactivation group showed no evidence of either recall or recognition memory. The group had a baseline ratio that was not significantly greater than 1.0, a retention ratio that was significantly less than 1.0, and a slight negative savings ratio. Thus for this group kicking in the initial 3 minutes of Day 16 was at the pretraining level and their performance during the reinforcement phase of Day 16 was similar to that of Day 1. When individual scores were inspected, only 1 of the 8 infants in the no reactivation group showed evidence of retention over 2 weeks. That the reactivation group and not the no reactivation group remembered the operant over 2 weeks is consistent with previous findings (Sullivan, 1982). It is not however, consistent with our findings in Experiment 1. The better retention of the reactivation group in this study is most likely due to the procedural changes made.

It might be argued that seeing the mobile in motion on Day 15 of itself might account for the reactivation group's response on Day 16. The no training control group's

response in the initial 3 minutes of Day 16 suggests otherwise. Although exposed to the reactivation treatment, the initial kick rate of infants in the no training group on Day 16 remained at the pretraining level.

The first training session of infants in the no training control group, which took place on Day 16, did not differ significantly from that of the reactivation and no reactivation group which occurred on Day 1. This finding suggests that the performance of infants in the reactivation and no reactivation groups was not a consequence of maturation. While there was no group effect, there was a significant Group x Block effect with infants in the no training control and reactivation groups kicking less than the no reactivation group on blocks 4 and 5. It is possible that the decrease in response on block 4 by both groups reflects a loss of interest in the task. When the task changed under extinction, the reactivation group's interest may have been revived and the group responded with increased kicking. In contrast, the no training group showed a further reduction in kicking. It may be that infants in the no training control group, whose major experience with the mobile tended to be that it did not move, might be quicker to stop kicking during the extinction phase than either of the other two groups.

The changes made in procedure seem to account for our being able to replicate the reactivation effect with 3-month-old fullterm infants in Study 2. These modifications in procedure were therefore incorporated to Study 3, which is the study of longterm memory in low risk preterm infants.

## Experiment 3

The purpose of Experiment 3 was to use the mobile conjugate reinforcement paradigm to compare the learning and longterm memory capacities of complication-free, hypoglycemic, and mild respiratory complications preterm infants to those of fullterm infants at an equivalent biological age. Longterm memory of infants was tested under the reactivation condition which is the optimal remembering condition. Infants received two 15-minute training sessions on Days 1 and 2, a reactivation session on Day 15, and a 2-week longterm retention test on Day 16.

### Method

Subjects. Subjects were 10 complication-free fullterm, 10 complication-free preterm, 8 hypoglycemic preterm, and 5 mild respiratory complication preterm singletons recruited from infants born at the Jewish General Hospital in Montreal between January, 1988 and March, 1991. There were 4 males and 6 females in both the complication-free preterm and fullterm groups, 3 males and 5 females in the hypoglycemic group, and 3 males and 2 females in the mild respiratory complications group. All infants were delivered vaginally with the exception of 5 infants (2 fullterms, 1 complication-free preterm, 1 hypoglycemic preterm, and 1 mild respiratory complication preterm) who were delivered by C-Section (4 repeat, 1 mother requiring surgery). An additional 5 infants were lost for excessive crying during the training phase (1 hypoglycemic preterm, 2 fullterms ) and illness prior to testing (1 complication-free preterm, 1 respiratory complications preterm). An additional 3 preterm infants were tested but subsequently found to have hypoglycemia plus one other medical complication.

To be eligible to participate in the study, infants had to be born to mothers who experienced uneventful pregnancies and who were free of maternal complications such as diabetes. Infants had to be described by their mother as being in good health, as not

having required hospitalization after the time of discharge, and not suffering from any infection such as the flu at the time of testing.

The criteria for the selection of preterm infants were established in consultation with the chief neonatologist at the Jewish General Hospital. The general criteria for the selection of all preterm infants were: GA of 32 to 36 weeks, appropriate weight for gestational age (AGA), no fetal distress, no congenital anomalies, no hearing or visual deficit, no heart problems, no asthma or allergies, no history of mechanical ventilation (except for the respiratory complications subjects), a bilirubin count under 15, and a 1-min and 5-min Apgar score of at least 7. In addition to meeting these criteria, preterm infants in the complication-free group had not suffered from any known complications. In addition to meeting the general criteria, infants in the hypoglycemic group had blood glucose levels below 30 mg per cent (see Appendix B for specific information on individual infants).

Preterm infants in the mild respiratory complications group included infants diagnosed as suffering from mild RDS or Transient Tachypnea of the newborn, as well as those without such diagnoses who presented with one or more of the following symptoms: grunting, tachypnea, retractions of the chest wall, or cyanosis. If ventilatory assistance was required, infants did not receive more than 40 percent oxygen. Preterm infants who were said to have suffered from moderate or severe RDS were excluded from the study. Downes, Vidyasagar, and Morrow's (1970) Clinical Respiratory Distress Scoring System (CRDSS), a 5-item scale which rates infants on respiration rate, cyanosis, retraction, grunting, and air entry, was completed for infants in the mild respiratory complications group. Infants who score less than 4 on this scale at 24 to 30 hours are said to have a good prognosis. The mean score of the respiratory complications group on the CRDSS was 1.2 with scores ranging from 0 to 3. Three infants in the

respiratory complications group presented with hypocalcemia. See Appendix B for information on the nature of complications experienced by subjects in this group.

Fullterm infants were selected from clinically healthy complication-free infants of AGA. They had a BW of at least 2900 g, a GA of 38 to 42 weeks, and 1-min and 5-min Apgar scores of at least 7.

Littman and Parmalee's Obstetric Complications Scale (OCS), a 41-item scale which measures maternal medical history, and their Postnatal Complications Scale (PCS), a 10-item scale which measures the occurrence of RDS, infections, ventilatory assistance, metabolic and temperature disturbances, convulsions, hyperbilirubinemia, and surgery (Littman & Parmalee, 1974), were completed from infants' medical files at the end of the study. Each item on these scales is scored as optimal or nonoptimal. Raw scores are converted to a scale with a mean of 100 and a standard deviation of 20, with higher scores reflecting fewer complications (see Appendix M for a copy of the scales).

Table 9 shows infant characteristics including scores on the Littman and Parmalee scales. Parental characteristics are summarized in Table 10.

One-way ANOVAs revealed no significant differences between preterm groups on BW, GA, Apgar scores at 1 and 5 minutes, chronological age at testing, and bilirubin count. Fullterm infants differed from preterm infants on BW, $F(3, 29) = 63.6$, $p < .001$, GA, $F(3, 29) = 81.8$, $p < .001$, and chronological age at testing, $F(3, 29) = 72.3$, $p < .001$. Fullterm infants were heavier, more mature at birth in terms of GA, and younger in chronological age at time of test than preterm infants. The hypoglycemic preterm group had significantly lower blood glucose levels than the other two preterm groups, $F(2, 20) = 4.51$, $p < .05$. Group differences also emerged on the Postnatal Complications Scale (PCS), $F(3, 29) = 20.99$, $p < .001$, on the Obstetric Complications Scale (OCS), $F(3, 29) = 6.52$, $p < .01$, and on days in hospital, $F(3, 29) = 10.61$, $p < .001$. Tukey tests revealed that the PCS scores of complication-free preterm and

Table 9

Characteristics of Preterm and Fullterm Infants

| | Group | | | |
|---|---|---|---|---|
| | Fullterm | Compl-Free Preterm | Hypoglycemic Preterm | Resp Compl Preterm |
| BW (gms) | | | | |
| Mean | 3619.5 | 2226.0 | 2190.0 | 2232.0 |
| S.D. | 325.4 | 219.0 | 221.6 | 300.9 |
| Range | 3150-3990 | 1880-2550 | 1880-2600 | 1850-2670 |
| GA (weeks/days) | | | | |
| Mean | 39/6 | 34/5 | 33/5 | 34/5 |
| S.D. | 0/2 | 1/1 | 1/1 | 0/6 |
| Range | 39/2-40/4 | 32-36 | 32/3-35/6 | 33/6-36 |
| Apgar 1-min (5-min) | | | | |
| Mean | 8.4 (9.1) | 8.1 (9.1) | 8.0 (9.0) | 7.8 (9.0) |
| S.D. | 0.5 (0.3) | 0.3 (0.3) | 0.5 (0.5) | 0.8 (0.7) |
| Range | 8-9(9-10) | 8-9(9-10) | 7-9(8-10) | 7-9(8-10) |
| Days in Hospital | | | | |
| Mean | 3.3 | 8.5 | 12.4 | 15.0 |
| S.D. | 1.6 | 0.5 | 0.5 | 0.5 |
| Range | 2-7 | 3-17 | 4-20 | 10-21 |

continued on next page...

Table 9 (continued)

| | | Group | | |
|---|---|---|---|---|
| | Fullterm | Compl-Free Preterm | Hypoglycemic Preterm | Resp Compl Preterm |
| Lowest Blood Sugar Level | | | | |
| Mean | - | 41.8 | 18.0 | 47.2 |
| S.D. | - | 28.5 | 5.4 | 7.2 |
| Range | - | 36.0-95.5 | 7.2-23.4 | 37.8-54.1 |
| Highest Bilirubin | | | | |
| Mean | - | 10.1 | 10.6 | 11.5 |
| S.D. | - | 4.7 | 1.4 | 1.9 |
| Range | - | 3.5-14.7 | 7.8-12.1 | 9.1-14.3 |
| Postnatal Complications Scale | | | | |
| Mean | 160.0 | 154.4 | 101.1 | 134.2 |
| S.D. | 0.0 | 17.7 | 8.1 | 35.8 |
| Range | 160 | 104-160 | 81-104 | 87-160 |
| Obstetric Complications Scale | | | | |
| Mean | 134.6 | 108.0 | 114.6 | 110.8 |
| S.D. | 16.3 | 16.1 | 8.9 | 14.2 |
| Range | 115-160 | 81-131 | 98-122 | 93-131 |

Table 10

Parental Characteristics of Fullterm and Preterm Infants

| | Group | | | |
|---|---|---|---|---|
| | Fullterm | Compl-Free Preterm | Hypoglycemic Preterm | Resp Compl Preterm |
| Maternal Age | | | | |
| Mean | 30.7 | 28.6 | 31.2 | 26.0 |
| S.D. | 3.2 | 4.6 | 3.4 | 3.6 |
| Range | 24-36 | 20-36 | 27-36 | 21-30 |
| Paternal Age | | | | |
| Mean | 31.5 | 31.0 | 32.5 | 33.0 |
| S.D. | 3.9 | 5.3 | 7.2 | 0.7 |
| Range | 26-42 | 21-37 | 23-44 | 32-34 |
| Maternal Education | | | | |
| Mean | 15.7 | 14.1 | 13.9 | 12.0 |
| S.D. | 3.5 | 2.6 | 3.4 | 2.1 |
| Range | 11-22 | 11-20 | 10-19 | 10-15 |
| Paternal Education | | | | |
| Mean | 16.4 | 14.0 | 14.9 | 13.2 |
| S.D. | 5.5 | 3.1 | 2.9 | 3.7 |
| Range | 10-30 | 9-20 | 12-20 | 8-18 |

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Table 10 (continued)

| | Group | | | |
|---|---|---|---|---|
| | Fullterm | Compl-Free Preterm | Hypoglycemic Preterm | Resp Compl Preterm |
| Birthplace | | | | |
| Both Canada | 7 | 9 | 3 | 2 |
| One Canada | 2 | 0 | 3 | 2 |
| Other | 1 | 1 | 2 | 1 |
| Language Spoken in the Home | | | | |
| English | 7 | 3 | 4 | 3 |
| French | 1 | 3 | 1 | 1 |
| Eng/French | 1 | 3 | 2 | 1 |
| Other | 1 | 1 | 1 | 0 |
| Hollingshead Index of Social Position | | | | |
| Mean | 3.0 | 2.2 | 2.6 | 2.8 |
| S.D. | 1.6 | 0.8 | 0.9 | 1.0 |
| Range | 1-5 | 1-4 | 2-4 | 1-4 |

fullterm infants were not significantly different from one another, but that both groups' scores were significantly higher than those of the hypoglycemic and respiratory complications groups, $p < .05$. The fullterm infants' scores on the OCS were significantly higher than those of the complication-free preterm infants, $p < .05$, but not significantly different from those of the other preterm groups. There were no significant differences between preterm groups on the OCS scores. Tukey tests showed that the difference in days spent in hospital between fullterm and complication-free preterm infants was not significant. Both of these groups spent significantly less time in hospital than the respiratory complications group, $p < .05$ . The fullterm group also spent significantly less time in hospital than the hypoglycemic group, $p < .05$. The difference between the complication-free and the hypoglycemic preterm groups was not significant. Finally, there were no significant group differences on parental characteristics. The ANOVA summary tables for the analyses of infant and parent characteristics are found in Appendix B.

Apparatus. The equipment used in Experiment 3 was identical to that used in Experiment 2.

Procedure. Every 3 or 4 weeks, the list of all preterm infants born at the Jewish General Hospital was reviewed for potential subjects. Preterm infants whose descriptions appeared to meet the selection criteria were noted and their medical record was examined after they were discharged from hospital. At each hospital visit, files of fullterm infants currently in hospital were also inspected. The pediatricians of infants who met the selection criteria were then contacted by letter (see Appendix A) and asked if they could speak to the mothers of these infants and get them to consent to be called by the researcher to discuss the study further. Mothers who agreed to the call were contacted one week prior to the date their infant was due to be tested. During the telephone conversation, they were given a brief description of the study and its purpose,

their questions were answered, and they were asked to participate. If they agreed, the first of 4 home visits was scheduled 12 to 14 weeks after the infant's expected date of birth at a time of day deemed by the mother to be an alert-play period for her infant. The consent form is found in Appendix A. All infants in this study received the same treatment as that of the reactivation group of Experiment 2. That is, they were given two 15-minute training sessions (Day 1 and 2), a 3-minute reactivation treatment on Day 15, and a 15-minute longterm memory test on Day 16. If infants cried for more than one minute towards the latter part (block 4 or 5) of one of the two training sessions and could not be consoled, the session was terminated and the data were prorated. Sessions were shortened for 4 of the 8 hypoglycemic preterm (Day 1 Block 4, 1 infant; Day 2 Block 4, 2 infants; Day 2 Block 5, 1 infant) and 1 complication-free preterm infant (Day 1 Block 5) (see Appendix B for a detailed description of these infants).

As in Experiments 1 and 2, footkicks and visual attention were later scored from videotapes by a trained rater, blind to the experimental hypotheses, the infant's group membership, and the visit being viewed. Rater reliability, obtained as before for 100% of footkick data and 20% of visual attention data was 86% for footkicks and 98.6% for visual attention. Only the blind rater's scores were used for analysis.

## Results

Preliminary Analysis of Training Session Footkick Data. Inspection of the baseline footkick data showed that 4 infants (1 fullterm, 2 complication-free preterms, and 1 hypoglycemic preterm) produced less than 2 kicks per minute. To reduce the likelihood of these infants meeting the learning criterion by chance, their baseline scores were increased to 2 kicks per minute. The footkick data of Days 1 and 2 were then inspected and found to be positively skewed with a negative kurtosis. There was also greater variability in scores for the complication-free preterm group than for the other three groups across blocks 1 to 5 of Day 1 and block 1 of Day 2. Three of the 10 infants in the complication-free group had scores that exceeded 30 kicks per minute on 4 of these 6 blocks. An additional 2 infants increased their kicking to 30 kicks per minute by block 5 of Day 1. While these scores were high, only 3 of them had Z values that exceeded 3 standard deviations. As shown in Figure 10, these high kick rates led to a steeper learning curve for the complication-free preterm group than for the other three groups on Day 1. Given the greater variability in one of the four groups, and the positive skewness and negative kurtosis of the data, Levene's test of homogeneity of variance was used to calculate whether the data met the assumption of homogeneity of variance. No significant Group, Day, or Block effects were found. Subsequent analyses were therefore done using the original footkick data.

Operant Acquisition. The pretraining levels of kicking by fullterm, complication-free preterm, hypoglycemic preterm, and respiratory complications preterm infants were compared to ensure that the groups did not differ prior to training. A Group (4) X Minute (3) ANOVA indicated no significant group or minute effect.

Table 11 shows the number of infants in each group who met the learning criterion of kicking 1.5 times their baseline level on Day 1 and Day 2, as well as those

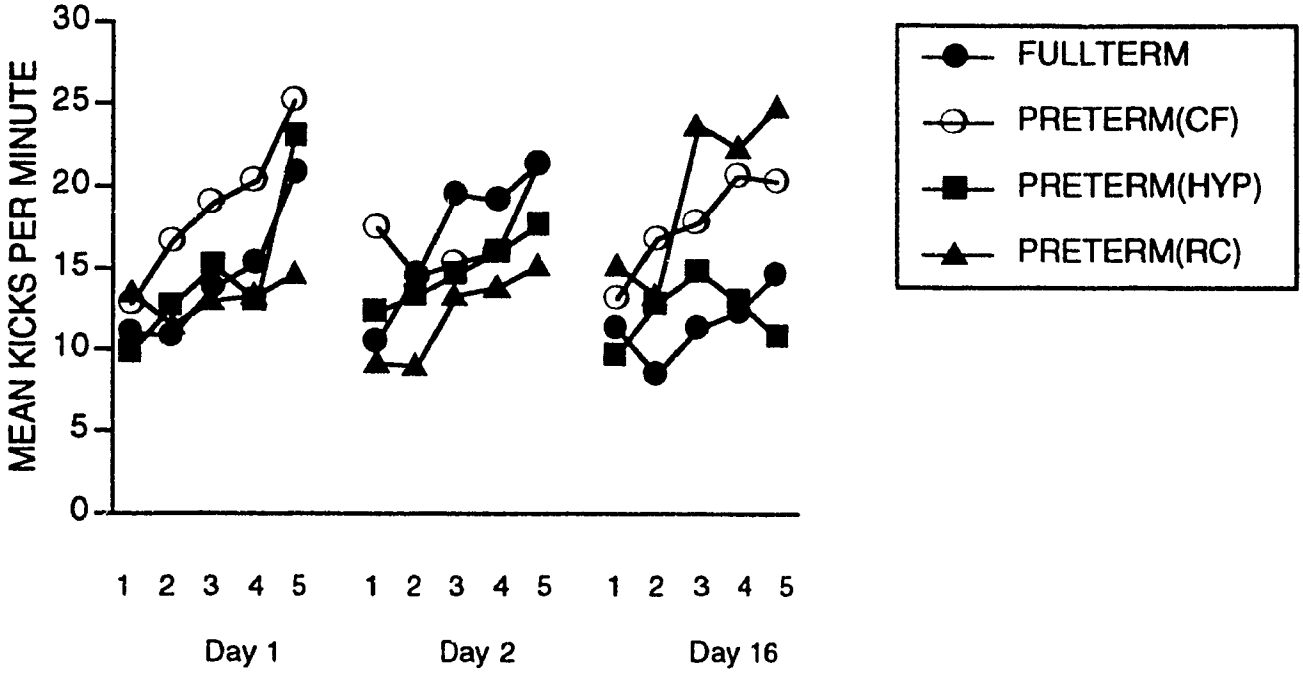


Figure 10. Experiment 3 mean kicks per minute during baseline (block 1) reinforcement (blocks 2-4) and extinction (block 5) phases of Day 1, 2, and 16.

Table 11

Number of Infants Per Group Who Met the Learning Criterion on Day 1 and Day 2, and Those Who Failed to Learn Within Two Training Days

| | Learn | | Did Not Learn |
|---|---|---|---|
| | Day 1 | Day 2 | |
| Group | | | |
| Fullterm | 9 | 1 | 0 |
| Compl Free Preterm | 6 | 4 | 0 |
| Hypoglycemic Preterm | 7 | 0 | 1 |
| Resp Compl Preterm | 2 | 1 | 2 |

infants who had not yet met the learning criterion after two training days. A Chi-square test was conducted to see if a relationship existed between group membership and whether or not infants met the learning criterion on Day 1. The result of the Chi-square test was not significant. The groups were then compared to see whether there was a relationship between group membership and whether or not infants learned the task. A significant relationship between these two factors emerged, $X^2(3, N = 33) = 7.95$, $p < .05$.

The Day 1 and 2 footkick data were then submitted to a Group (4) X Day (2) X Block (5) ANOVA. A significant effect of Block was found, $F(4, 116) = 11.36$, $p < .001$, with kicking increasing across blocks 1 through 5. Tukey tests revealed that kicking in block 5 was significantly higher than in blocks 1 and 2, $p < .01$.

Additional group comparisons were made involving the 24-hour baseline, retention, and savings ratios (see Table 12). One-way ANOVAs were computed for each ratio. No significant group differences emerged.

24-Hour Retention. To test whether infants showed evidence of recall, or memory for the association without seeing the mobile in motion, each group's 24-hour baseline and retention ratios were compared to the theoretical value of 1.0 using t-tests. None of the groups had a baseline ratio that was significantly greater than 1.0. In addition, the retention ratios of the fullterm infants and respiratory complication preterm infants were significantly different from 1.0. Infants in these groups kicked less in the initial 3 minutes of Day 2 than they had done in the last 3 minutes of Day 1, $t(9) = 7.5$, $p < .001$ for fullterm infants and $t(4) = 2.44$, $p < .05$ for respiratory complication preterm. The hypoglycemic and complication-free preterm infants' kick rate at the beginning of Day 2 was not significantly different from that at the end of Day 1.

Table 12

Mean 24-Hour and 2-Week Baseline, Retention, and Savings Ratios

| | Baseline | Retention | Savings |
|---|---|---|---|
| Groups | 24-HR / 2-WK | 24-HR / 2-WK | 24-HR / 2-WK |
| Fullterm (N = 10) | | | |
| Mean | 1.5 / 1.1 | 0.5***/ 0.5** | 0.4** / ⁻0.1 |
| S.D. | 1.3 / 0.7 | 0.2 / 0.4 | 0.4 / 0.3 |
| Range | 0.5-5.0 / 0.3-2.4 | 0.3-0.9 / 0.1-1.5 | ⁻0.3-1.0 / ⁻0.7-0.2 |
| Complication-Free Preterm (N = 10) | | | |
| Mean | 1.3 / 2.2 | 0.8 / 0.8 | 0.1 / 0.6 |
| S.D. | 1.3 / 3.1 | 0.7 / 0.8 | 0.6 / 1.4 |
| Range | 0.0-5.0 / 0.4-10.5 | 0.0-1.9 / 0.2-2.8 | ⁻0.6-0.9 / ⁻0.5-4.3 |
| Hypoglycemic Preterm (N = 8) | | | |
| Mean | 1.6 / 1.1 | 0.6 / 0.6 | 0.2 / ⁻0.1 |
| S.D. | 1.2 / 1.3 | 0.3 / 0.7 | 0.6 / 0.4 |
| Range | 0.6-4.0 / 0.2-4.3 | 0.2-1.1 / 0.1-2.2 | ⁻0.8-1.1 / ⁻0.6-0.7 |
| Respiratory Complications Preterm (N = 5) | | | |
| Mean | 0.8 / 1.1 | 0.6* / 0.9 | 0.0 / 0.3 |
| S.D. | 0.7 / 0.8 | 0.4 / 0.6 | 0.3 / 0.7 |
| Range | 0.0-1.6 / 0.2-2.1 | 0.1-1.1 / 0.4-1.9 | ⁻0.5-0.3 / ⁻0.3-1.4 |

* $p < .05$. ** $p < .01$. *** $p < .001$.

Each infant's baseline and retention ratios were then reviewed to see how many infants in each group showed evidence of perfect or intermediate retention over 24 hours. Of the infants who met the learning criterion by the end of Day 1, 2 of the 9 fullterm (22%), 2 of the 6 complication-free preterm (33%), 2 of the 7 hypoglycemic preterm (28.6%), and 1 of the 2 respiratory complication preterm (50%) infants showed evidence of perfect retention with a baseline ratio of 1.5 or greater and a retention ratio that exceeded 0.70. An additional 2 fullterm infants showed evidence of intermediate retention with a baseline ratio of 1.5 or greater.

To test for recognition memory, or how infants responded when kicking was effective in making the mobile move, each group's savings ratio was compared to the theoretical value of 0. Only the fullterm infants' savings ratio was significantly different from 0, $t(9) = 3.0$, $p < .01$. (see Appendix J)

Day 16 Longterm Memory Test. The Day 16 performance of all four groups was first subjected to Levene's test of homogeneity of variance and then compared by means of a Group (4) X Block (5) ANOVA. A significant effect of Block was found, $F(4, 104) = 2.84$, $p < .05$, with infants showing increased kicking across blocks 1 through 5. Tukey tests revealed a significant difference between blocks 1 and 5 only, $p < .05$. One-way ANOVAs of 2-week baseline, retention, and savings ratios revealed no significant group differences. The 2-week ratios are shown in Table 12.

To test for longterm memory, each group's 2-week baseline and retention ratios were compared to the theoretical value of 1.0 using directional t-tests. There was no evidence of recall after 2 weeks by either the fullterm or hypoglycemic preterm groups. Fullterm infants' 2-week baseline ratio was not significantly different from 1.0 and their retention ratio was significantly smaller than 1.0, $t(9) = 3.7$, $p < .005$. Similarly, hypoglycemic infants' baseline ratio was not significantly different from 1.0

and their retention ratio was significantly different from 1.0, albeit only at the .10 level, $t(7) = 1.56$, $p < .10$. The data from both complication-free preterm and respiratory complications preterm groups suggested some evidence of retention over 2 weeks. The baseline ratio of the complication-free preterm group was significantly different from 1.0 at $p < .15$, $t(9) = 1.21$. When one considered all respiratory complication preterm infants including the two that did not learn, the group's baseline ratio was not significantly different from 1.0. If, however, one considered only those infants who met the learning criterion, the baseline ratio was significantly different from 1.0 at $p < .10$, $t(2) = 2.54$. Both groups' retention ratios were not significantly different from 1.0.

To test for recognition memory, each group's savings ratio was compared to a theoretical value of 0. Consistent with the findings for recall memory, fullterm and hypoglycemic preterm groups showed no evidence of recognition memory, whereas there was evidence to suggest some recognition by the complication-free preterm group and those respiratory complications preterm infants who met the learning criterion. The fullterm and hypoglycemic preterm groups' savings ratio were not significantly different from 0. The complication-free preterm group's savings ratio was significantly different from 0 at the $p < .15$ level, $t(9) = 1.27$. Infants in the respiratory complications group who learned the operant had a savings ratios that was significantly different from 0 at $p < .10$ , $t(2) = 1.91$.

When individual 2-week baseline and retention ratios of infants who met the learning criterion by the end of Day 2 were inspected, 4 of the 10 (40%) complication-free preterm infants and 1 of 7 (14%) hypoglycemic preterm infants showed evidence of both recall and recognition memory with a baseline ratio of 1.5 or greater and a savings ratio in excess of 0.25. All 3 of the respiratory complications preterm infants who learned the operant showed evidence of retention, 2 showing evidence of recall with

a baseline ratio of 1.5 or greater, and the third infant showing evidence of recognition with a savings ratio greater than 0.45. Three of the 10 (30%) fullterm infants who met the learning criterion by the end of Day 2 showed evidence of recall with baseline ratios of 1.5 or greater. These infants' savings ratios did not exceed 0.25. The analyses are found in Appendix K.

Visual Attention. The mean seconds per minute each group spent looking at the mobile across the baseline, reinforcement, and extinction phases of Days 1, 2, and 16 is shown in Table 13. The Day 1 and 2 visual attention data were subjected to Levene's test of homogeneity of variance and a significant Group X Day interaction, $F(3, 26) = 4.53$, $p < .01$,was found. Inspection of the data suggested that the interaction was attributable to the hypoglycemic group which had more extreme z scores on Day 2 than Day 1. The data were transformed using a reciprocal transformation and then tested for homogeneity of variance. The Group X Day interaction was again significant, $F (3, 26) = 4.58$, $p < .01$. Consequently, subsequent analyses were done using the raw scores rather than transformed scores (Keppel, 1973). Day 1 and 2 visual attention data were compared by means of a Group (4) X Day (2) X Phase (3) ANOVA. The analysis revealed only a significant Group X Day interaction, $F(3, 26) = 4.28$, $p < .01$. Figure 11 shows that the fullterm, complication-free preterm, and respiratory complication preterm groups all looked at the mobile more on Day 2 than Day 1. This was not the case, however, for the hypoglycemic group who on Day 2 spent less time looking at the mobile.

A one-way ANOVA was run to compare the groups' visual attention during the reactivation phase of treatment. There was no significant group differences in visual attention during reactivation.

Because Levene's test of homogeneity of variance on the Day 16 visual attention data showed a significant difference in group variance, $F(3, 26) = 3.37$, $p < .05$, that was not removed by reciprocal transformation of the scores, the original visual

Table 13

Mean Visual Attention Scores (seconds per minute) For All Phases of Each Day

| | Day1 | | | Day 2 | | | Day 15 | Day 16 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Phase[a] | | | Phase[a] | | | Phase[a] | Phase[a] | | |
| | B | R | E | B | R | E | P | B | R | E |
| Fullterm (N = 10) | | | | | | | | | | |
| Mean | 49 | 59 | 53 | 58 | 58 | 55 | 58 | 56 | 57 | 49 |
| S.D. | 12 | 2 | 13 | 2 | 3 | 9 | 3 | 4 | 4 | 14 |
| Complication-Free Preterm (N = 10) | | | | | | | | | | |
| Mean | 53 | 57 | 45 | 51 | 54 | 51 | 51 | 47 | 51 | 41 |
| S.D. | 6 | 5 | 18 | 10 | 14 | 18 | 9 | 8 | 6 | 15 |
| Hypoglycemic Preterm (N = 8) | | | | | | | | | | |
| Mean | 46 | 54 | 52 | 44 | 51 | 43 | 51 | 46 | 55 | 45 |
| S.D. | 10 | 7 | 13 | 11 | 10 | 22 | 13 | 13 | 4 | 15 |
| Respiratory-Complications Preterm (N = 5) | | | | | | | | | | |
| Mean | 55 | 56 | 50 | 57 | 58 | 54 | 53 | 59 | 56 | 50 |
| S.D. | 3 | 6 | 11 | 3 | 3 | 11 | 9 | 2 | 4 | 10 |

[a] B Baseline Phase R Reinforcement Phase E Extinction P Reactivation

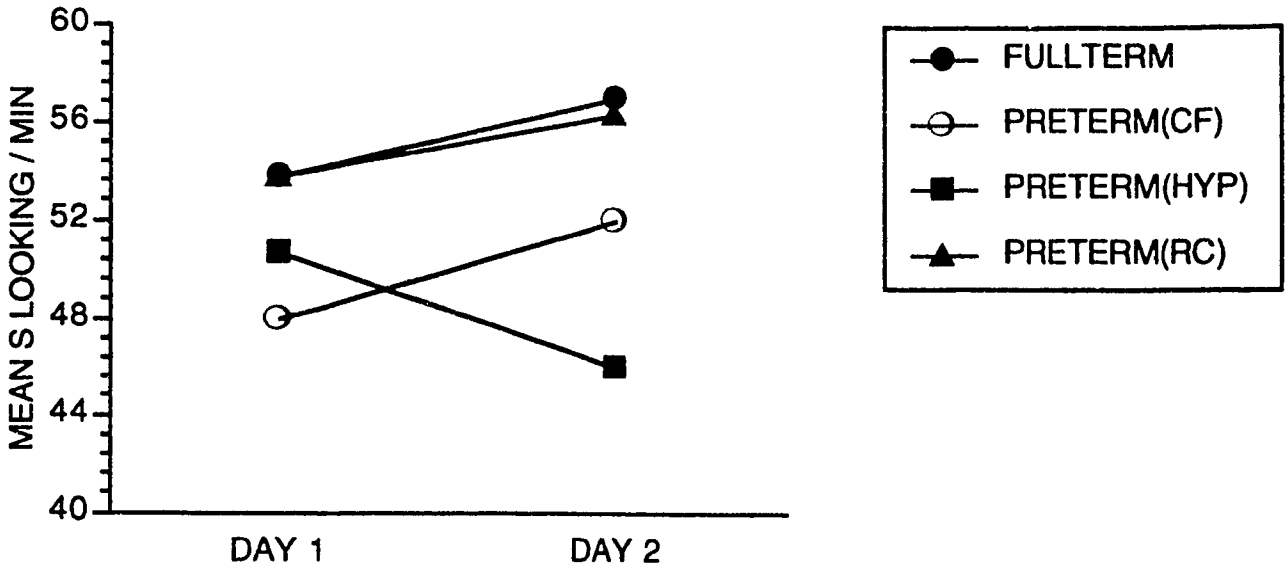


FIGURE 11. Experiment 3 Group X Day interaction in mean visual attention over all phases on training days.

attention data of Day 16 were compared by means of a Group (4) X Phase (3) ANOVA. A significant effect of phase emerged, $F(2, 52) = 6.51$, $p < .01$. Tukey tests indicated that infants spent more time looking at the mobile during baseline, $p < .05$, and reinforcement, $p < .01$, than during extinction (see Figure 12).

Spearman rank correlations were calculated between visual attention and kick rate for each phase of Days 1, 2 and 16 for each group. There was a tendency for kick rate to be positively correlated with visual attention during the reinforcement phase of Days 1 and 2. Visual attention during the reinforcement phase of Day 1 was then correlated with the 24-hour baseline and retention ratios. There was no evidence of a significant relationship between these measures. Finally, the mean of the Day 1 and 2 visual attention data during the reinforcement phase were correlated with the longterm baseline and retention ratios. No significant relationship was found between these measures. (see Appendix L)

Hypoglycemic Preterm Infants With One Other Complication. The data of the three hypoglycemic preterm infants who had suffered one other complication: hyperbilirubinemia (N = 1), C-Section because of vaginal bleeding (N = 1), and respiratory complication (N = 1), were reviewed to see whether these infants had acquired the operant within two training days and showed evidence of retention at 24 hours and 2 weeks. Two of the three infants met the learning criterion by kicking more than 1.5 times their baseline level on Day 1. In contrast, the hypoglycemic preterm infant who had suffered hyperbilirubinemia had not yet met the learning criterion by the end of two training days. Of the three infants, only one (the infant born by C-Section) showed evidence of retention both at 24 hours and 2 weeks with baseline ratios greater than 4.0, and retention and savings ratios above 1.0.

Analyses With Larger Fullterm Group. The fullterm group in Experiment 2 who received a reactivation treatment showed evidence of retention on the longterm memory

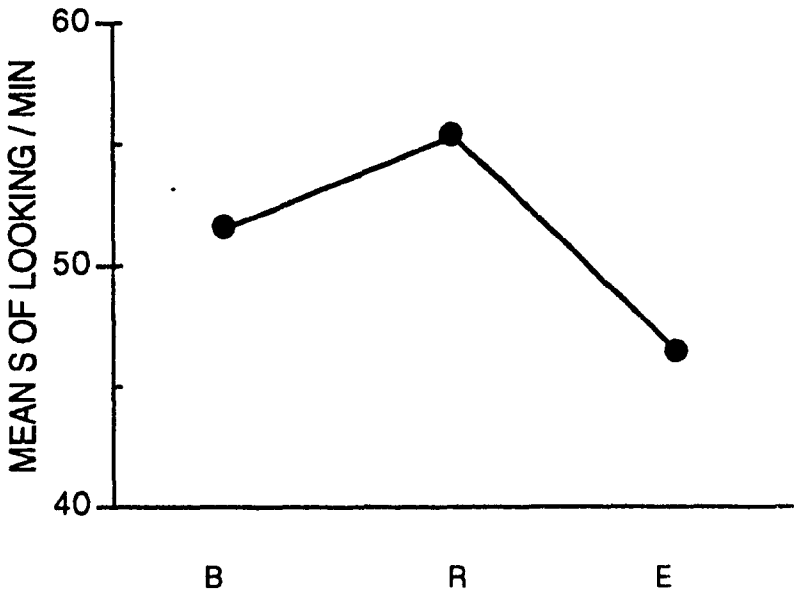


Figure 12. Experiment 3 Day 16 Phase effect of visual attention collapsed over groups.

test, but a second group of fullterm infants (Experiment 3) tested under identical conditions did not. These two fullterm reactivation groups were compared on infant and parental characteristics, and on acquisition data to see if some factor could account for the differences in longterm retention they exhibited. The groups were found to be similar on all infant and parental characteristics, as well as on kick rate, number of infants who met the learning criterion by Day 1, 24-hour retention, and visual attention. Because the fullterm reactivation groups of Experiment 2 and 3 were found to be similar on these measures although recruited differently, the difference in longterm retention between the groups was thought to be due to sampling error. To get a better estimate of fullterm infants' performance on the conjugate reinforcement task, the Experiment 2 and 3 data of fullterm infants tested under the reactivation condition were combined. The preterm groups were then compared to this larger sample of fullterm infants.

Operant Acquisition. Levene's test of homogeneity of variance was calculated using the complication-free, hypoglycemic, and respiratory complication preterm infants' and the fullterm infants' Day 1 and 2 footkick data. No significant difference in group variance was found. To ensure that the groups did not differ on baseline performance, their kick rate across the first three minutes of Day 1 was compared by means of a Group (4) X Minutes (3) ANOVA. There was no significant Group or Minute effect and no significant interaction. A Group (4) X Day (2) X Block (5) ANOVA of the footkick data for Days 1 and 2 revealed only a significant effect of Block, $F(4, 148) = 11.48$, $p < .001$, with infants showing an increase in kicking across blocks of Days 1 and 2. Tukey tests indicated that block 1 was significantly different from block 5, $p < .01$.

Additional group comparisons were done on the 24-hour baseline, retention, and savings ratios which were first subjected to Bartlett's test of homogeneity of variance. Only the groups' baseline ratios were found to violate the assumption of homogeneity of

variance, $X^2$ (3, N = 41) = 23.26, p < .001. A Kruskal-Wallis one-way ANOVA was therefore used to test for group differences in baseline ratios. No significant group difference emerged. The groups' retention and savings ratios were compared by means of a one-way ANOVA and no significant differences were found.

Then to test for memory over 24 hours, the larger fullterm group's 24-hour baseline and retention ratios were compared to the theoretical value of 1.0, and its 24-hour savings ratio was compared to 0. The group showed evidence of recognition after 24 hours with a savings ratio significantly greater than 0, t(17) = 2.36, p < .025, but no evidence of recall because the 24-hour baseline ratio was not significantly greater than 1.0 and the retention ratio was significantly less than 1.0, t(17) = 2.37, p < .025. The 24-hour ratios for the larger sample of fullterm infants are found in Table 14. The summary tables for the analyses are found in Appendix N.

Day 16 Longterm Memory Test. Levene's test of homogeneity of variance on the Day 16 footkick data indicated no significant differences in group variance. The data were then subjected to a Group (4) X Block (5) ANOVA. The only significant finding was an effect of Block, F(4, 152) = 3.07, p < .02, with kick rates in block 1 being significantly lower than in block 3, p < .05. Because Bartlett's tests showed group differences in variance for the baseline and savings ratios, these ratios were compared using a Kruskal-Wallis one-way ANOVA and the retention ratios were compared using a one-way ANOVA. There were no significant group differences on any of the ratios.

To test for longterm recall, the larger fullterm group's 2-week baseline and retention ratios were compared to the theoretical value of 1.0, and their savings ratio was compared to the theoretical value of 0. The baseline ratio was found to be significantly greater than 1.0, t(17) = 2.05, p < .05. Thus infants kicked more during the initial 3 minutes of Day 16 than during the initial 3 minutes of Day 1 for the retention ratio. The retention ratio was also significantly different from 1.0, t(17) =

Table 14

Mean 24-Hour and 2-Week Baseline, Retention, and Savings Ratios For the Larger Fullterm Sample

| | Baseline | Retention | Savings |
|---|---|---|---|
| Groups | 24-HR / 2-WK | 24-HR / 2-WK | 24-HR / 2-WK |
| Fullterm (N = 18) | | | |
| Mean | 2.2 / 1.4* | 0.7**/ 0.7** | 0.3** / 0.1 |
| S.D. | 3.9 / 0.9 | 0.5 / 0.5 | 0.3 / 0.6 |
| Range | 0.5-17.5 / 0.3-3.8 | 0.3-2.2 / 0.1-2.9 | -0.3-1.0 / -0.7-1.9 |

* $p < .05$. ** $p < .025$

2.46, $p < .025$, with less kicking occuring during the initial 3 minutes of Day 16 than during the last 3 minutes of Day 2. The savings ratio was not significantly different from 0. See Appendix O for the analysis summary tables.

Visual Attention. The Day 1 and 2 visual attention data of the fullterm, complication-free preterm, hypoglycemic preterm, and respiratory complications preterm infants were subjected to Levene's test of homogeneity of variance. No significant difference in group variance was found. The visual attention data were therefore compared by means of a Group (4) X Day (2) X Phase (3) ANOVA. A significant effect of Phase was found, $F(2, 66) = 3.96$, $p < .025$, with infants spending more time looking at the mobile during the reinforcement phase than during extinction, $p < .05$.

Visual attention scores during the reactivation treatment were subjected to a one-way ANOVA. The groups were not found to differ on the amount of time they spent looking at the mobile during the reactivation treatment. Finally, the Day 16 visual attention data were subjected to Levene's test of homogeneity of variance and a significant difference in group variance was found, $F(3, 34) = 3.61$, $p < .025$ with the respiratory complication preterm group's variance being significantly different from that of the complication-free preterm and hypoglycemic preterm infants. The visual attention data was then transformed and subjected to Levene's test of homogeneity of variance The Group effect remained significant, $F(3,34) = 3.46$, $p < .05$ in spite of the reciprocal transformation. The original visual attention data were therefore used to compare the groups on Day 16 visual attention. A Group (4) X Phase (3) ANOVA revealed a significant effect of Phase, $F(2, 68) = 8.31$, $p < .001$. Tukey tests indicated that infants spent more time looking at the mobile during the reinforcement phase than the extinction phase, $p < .05$. (see Appendix P)

Discussion

The purpose of Experiment 3 was to compare learning and longterm memory in fullterm, complication-free preterm, hypoglycemic preterm, and respiratory complication preterm infants 12 weeks after their expected date of birth using the mobile conjugate reinforcement paradigm. It was hypothesized that most of the fullterm infants would meet the learning criterion by the end of Day 1 and the remainder would do so by Day 2. It was also thought that complication-free preterms infants' response during training would be similar to that of fullterm infants. That is, both groups would learn the association between kicking and mobile movement, and they would not differ in terms of kick rate or time taken to meet the learning criterion. Preterm infants with complications were, on the other hand, expected to require more time than either complication-free preterm or fullterm groups to learn the task. With respect to memory, fullterm infants were expected to show evidence of retention 24 hours after the first training visit, and again on the longterm memory test 2 weeks later. Finally, it was thought that preterm infants who had experienced complications at birth, given slower learning, might show little evidence of retention over 24 hours. It was also thought that the reactivation treatment would be less effective, and they would have difficulty retrieving the memory 2 weeks after training.

With respect to acquisition, fullterm infants' response was as predicted and consistent with previous findings (Rovee & Rovee, 1969; Sullivan, 1982; Davis & Rovee-Collier, 1983) including those of Experiment 1 and 2. The fullterm group showed a significant increase in kicking across blocks of Days 1 and 2 and their kick rate was signficantly above their pretraining level by the end of Day 1. As in previous studies, the majority (90%) of fullterm infants met the learning criterion on the first day of training, and the remaining infant did so by the end of Day 2. When the 24-hour savings, baseline, and retention ratios were considered, the fullterm group showed

evidence of recognition memory, but not of recall. That is, the fullterm group remembered the operant when kicking produced mobile movement, but did not seem able to so in the initial 3 minutes of Day 2, when kicking was not associated with mobile movement. This occurred, in spite of their showing increased attention to the mobile in the first 3 minutes of Day 2 relative to the last 3 minutes of Day 1. That the fullterm group did not recall the operant after 24 hours in that their kicking in the initial 3 minutes of Day 2 was at the pretraining level, was consistent with the findings of Experiments 1 and 2. This behavior was, however, inconsistent with previous studies of 3-month-old fullterm infants (Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980; Rovee-Collier, Enright, Lucas, Fagen & Gekoski, 1981; Sullivan, 1982), with the exception of Fagen et al. (1981) and resembled instead the performance of 2-month-old fullterm infants reported by Greco, Rovee-Collier, Hayne, Griesler, and Earley (1986), and Hayne, Greco, Earley, Griesler, and Rovee-Collier (1986).

Analysis of the 2-week baseline, retention, and savings ratios of the Experiment 3 fullterm group showed no evidence of either recall or recognition memory. Instead, there was evidence of significant forgetting with infants kicking significantly less in the initial 3 minutes of Day 16 than at the end of Day 2. Data for individual infants indicated that as in Experiment 1, only 3 of the 10 (30%) fullterm infants showed evidence of recall at 2 weeks with a baseline ratio greater than 1.5. In Experiment 1, the findings were atttributed to infants having access to their own mobile after the reactivation treatment. In Experiment 3, however, fullterm infants did not have access to their own mobile between the reactivation treatment and the longterm memory test. In Experiment 2, the reactivation group showed evidence of recall and yet they were treated identically to infants in Experiment 3. Of the 8 infants in the reactivation group of Experiment 2, 4 or 50% had a 2-week baseline ratio that was 1.5 or greater. Comparisons between the fullterm reactivation groups of Experiment 2 and 3 yielded no

evidence of significant differences between the samples on infant or parental characteristics, or on kicking, visual attention, or rate of acquisition. The only difference between samples was the recruiting procedure with infants of Experiment 2 being recruited through birth announcements, whereas those of Experiment 3 were obtained through the hospital. It is unlikely that recruiting procedure could account for the difference in longterm memory between groups. Taken together, these findings suggest that there is greater variability in the reactivation effect among 3-month-old fullterm infants than has previously been reported.

When preterm and fullterm infants were compared, the complication-free preterm and fullterm groups were similar with respect to acquisition. That is, both groups showed a significant increase in kicking across blocks of Days 1 and 2, their rate of acquisition (or number of infants who reached criterion on Day 1 vs Day 2) was not significantly different, and all infants in both groups showed evidence of having acquired the operant by the end of the second training day. These finding are contrary to Gekoski, Fagen, and Pearlman (1984) whose sample of preterm infants failed to show a significant increase in kicking across blocks of Day 1 and acquired the operant only on Day 2. The poorer performance on acquisition by preterm infants in the Gekoski, Fagen, and Pearlman study may be attributable to the infants' history of complications since infants in the present research who had suffered complications were more likely to fail to learn the operant within two training days. While there were no significant group differences in response during acquisition, the complication-free preterm group's response was found to be more variable than that of the other preterm groups or the fullterm group on Day 1. When first exposed to the mobile in motion, infants in this group responded in one of two ways. Close to half of the group reached high levels of kicking (35 kicks or more per minute), whereas the other half of the group maintained very low kick rates (kicking never exceeding 9 kicks per minute). That only the

complication-free preterm group showed such a wide range in scores is of interest. It is possible that the complication-free preterm group's response reflects the impact of premature environmental stimulation on an immature system.

When the infants who learned were compared to those who did not learn, preterm infants who had suffered respiratory complications were more likely than the other groups to fail to meet the learning criterion. Two of five (40%) infants in the respiratory complication preterm group had not yet met the learning criterion by the end of Day 2. This percentage is unusually high given that only 1 of the 8 (12.5%) infants in the hypolgycemic group failed to meet the learning criterion. In addition, in Experiments 1, 2, and 3 the failure-to-learn rate for fullterm infants, excluding those infants that cried, was 3%, 8%, and 0% respectively. Moreover, in the few studies of fullterm infants where infants are said to have failed to meet the learning criterion, the rate is at most 5-10% (Sullivan, 1982; Butler & Rovee-Collier, 1989; Rovee-Collier & Dufault, 1991). Examination of available information for infants in the respiratory complications group who did not learn indicated that they differed from others in the group most obviously in having lower blood sugar levels that were marginal, but not low enough to meet the criterion for hypoglycemia.

Analysis of group data revealed evidence of recognition memory by the fullterm group at 24 hours with the group's savings ratio being significantly different from 0. There was, however, no evidence of recall by the fullterm group since the group's baseline ratio was not significantly greater than 1.0. In comparison, there was no evidence of either recall or recognition by the preterm groups at 24 hours. When individual infants' data were reviewed, however, and only those infants who had met the learning criterion by the end of Day 1 were considered, 4 of the 9 (44%) fullterm infants, 2 of the 6 (33%) complication-free preterm infants, 2 of the 7 (28.6%)

hypoglycemic infants, and 1 of the 2 (50%) respiratory complication preterm infant recalled the operant on the 24-hour memory test with a baseline ratio of 1.5 or greater.

At 2 weeks, there was no evidence of either recall or recognition memory by the fullterm group. There was also no evidence of significant differences between preterm and fullterm groups on baseline, retention, and savings ratios or on kick rate. When the data of Experiment 2 and 3 fullterm reactivation groups were combined to get a better estimate of fullterm infants' performance with respect to longterm memory, evidence of recall was found at 2 weeks with infants' baseline kick rate on Day 16 being significantly above that of Day 1. Evidence of recall was found for 7 of the 18 (38.9%) fullterm infants. When the data for the combined group were compared to those of preterm infants, no significant differences were found. There was, however, some evidence suggesting differences between the hypoglycemic group and the other three groups when individual ratios were inspected. Of the infants who learned the task, the 2-week baseline ratios showed that 40% of the complication-free preterm group, 66% of the respiratory complication group , but only 14% of the hypoglycemic group recalled the operant. The hypoglycemic preterm infants' poor recall was in spite of their having learned the association between mobile movement and kicking on Day 1. The hypoglycemic infants' inability to remember the association between kicking and mobile movement might be related to their greater tendency to fuss and cry. Recent work by Fagen, Ohr, and Fleckenstein (1985) showed that infants who cried during training sessions were unable to remember the association 1 week after training.

Further evidence of differences between the hypoglycemic group and the other groups emerged when visual attention was investigated. Unlike the other groups, hypoglycemic preterm infants spent less time looking at the mobile during Day 2. By spending less time on target , the hypoglycemic preterm infants were less likely to consolidate what they had learned on Day 1 and were possibly at greater risk for

forgetting what they had learned.

General Discussion

The purpose of the research was to investigate the impact of prematurity per se and of hypoglycemia and respiratory problems on infants' ability to learn to kick to make a mobile move, and on their ability to remember the association 2 weeks after training, when given a reactivation treatment 24 hours before the longterm memory test. The findings suggest that infants' ability to acquire the operant and to remember it on a longterm memory test were not affected by their being born prematurely. Like fullterm infants, complication-free preterm infants acquired the operant within two training days and close to half of the group showed evidence of longterm memory. These findings are consistent with previous studies which report similar performance of "healthy" preterm infants and fullterm infants on autonomic control (Fox, 1982), cardiac orienting to auditory stimuli (Fox & Lewis, 1983), and visual and auditory orienting (Duffy, Als, & McAnulty, 1990), and between complication-free preterm and fullterm infants on attention and short-term memory (Messmer, Taylor, & Papageorgiou, submitted for publication). While there were no significant differences between complication-free preterm and fullterm groups' ability to learn the operant and remember it over 2 weeks, the complication-free preterm group's initial response to the task was slightly different from that of the fullterm group. Half of the complication-free preterm group kicked at a relatively high rate, whereas the other half maintained low kick rates. The bimodal distribution of kick rates by complication-free preterm infants on Day 1 may reflect the effect, although subtle, of premature birth on cortical development (Turkewitz & Kenny, 1982; Duffy, Mower, Jensen, & Als, 1984).

When the respiratory complications and the hypoglycemic preterm infants were considered, there was some evidence suggesting differences between preterm infants who had suffered complications and those infants, both preterm and fullterm, who were free of complications. Infants in the respiratory complications group were more likely than

infants in any of the other groups to fail to learn the operant. Infants in the respiratory complication group who did not meet the learning criterion were not, however, infants whose respiratory complications were most severe. Instead, it was those infants who in addition to having a respiratory complication also had marginal blood glucose values. It may be that some infants who suffer more severe respiratory complications may escape unscathed because they are constitutionally less sensitive to biological insult resulting from their illness, and that infants who experience particular combinations of complications may be at greater risk for learning difficulties.

Hypoglycemic preterm infants in this study also appeared at risk, but the impact of hypoglycemia seemed different from that of respiratory complications. Preterm infants with hypoglycemia were least likely to remember the association on the longterm memory test in spite of having acquired the operant on Day 1, they appeared least interested in the mobile on the second day of training, and they were most likely to fuss and cry during training. The observed differences between the hypoglycemic preterm group and the other groups in this study are consistent with previous reports of greater risk of impairment in children who were hypoglycemic at birth (Fluge, 1975; Pildes et al., 1974; Ross, Kraus, & Auld, 1983). They differ, however, from Piekkala et al. (1988) who failed to find differences between hypoglycemic preterm and fullterm groups on developmental achievement at 2 years of age. The discrepancy between findings may be attributable to a combination of the sensitivity of the task, the skill being assessed, and the age at which infants were tested.

That the performance of preterm infants who had suffered respiratory complications or hypoglycemia was somewhat different from that of infants who were complication-free is consistent with numerous other studies which report differential responding by preterm infants with complications and fullterm infants (Siegel, 1983; Siegel et al., 1979; Field et al., 1981; 1983). The unique responses of hypoglycemic

and respiratory complications preterm infants point to the danger of treating infants with complications as if they were a homogeneous group and suggest the need to clarify the impact of different complications on learning and longterm memory (Fox & Lewis, 1983).

In two of the three experiments, the fullterm groups who had acquired the operant during the training phase and who received the reactivation treatment failed to show evidence of memory on the longterm memory test. The difficulty in replicating the reactivation effect may stem from methodological differences between the present research and previous studies. In the present work, the data analyzed was obtained from a rater who scored footkicks from videotapes and was blind to the infants' group membership, session being viewed, and hypotheses being tested. In previous studies, however, the majority of the data were recorded by a rater present during the session who could not have been blind to the particular session or time phase being scored. There is a danger that experimenter bias might have contaminated the findings.

Another difference between the present research and some of the earlier work is the measure of memory used. In the present work, the baseline ratio was thought to be the primary index of recall. Rovee-Collier and Dufault (1990) have recently referred to the baseline ratio as the measure of recall and have suggested that the retention ratio in and of itself does not provide evidence of retention. Prior to Davis and Rovee-Collier (1983), however, studies of the reactivation effect used the retention ratio as the measure of memory (Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980; Rovee-Collier, Enright, Lucas, Fagen, & Gekoski, 1981; Sullivan, 1982). Thus it is not clear whether there was evidence of the reactivation effect in these studies, since the baseline ratio was not used.

More recent studies of the reactivation effect that have included the baseline ratio suggest, moreover, that the reactivation treatment can be effective in alleviating

forgetting, but only under specific circumstances. For example, forgetting can be alleviated when the mobile and context during the reactivation treatment are the same as during training, but only if 2- and 6-component mobiles are used and not when a 10-component mobile is used. If the context is changed, even a 5-component mobile is not an effective retrieval cue. These findings have led Butler and Rovee-Collier (1989) to propose the contextual-gating model which suggests that retrieval can only take place if information in the test situation matches that encoded in memory. Thus if an infant fixates one component of the mobile during training, he/she must see that same component during the reactivation treatment and test session if they are to retrieve what they have learned. This may account for some infants not showing evidence of retention on the longterm memory test.

Across three experiments, more than half of the fullterm infants who received a reactivation treatment failed to show evidence of longterm retention. These findings suggest that there is considerable variability in 12-week-old fullterm infants' ability to use a reactivation treatment to retrieve an association. Numerous studies using the conjugate reinforcement paradigm to investigate memory have based their findings on samples of less than 8 infants per group (range between 4 and 8). Larger samples of fullterm infants (15 per group) are required to obtain replicable findings and provide a better estimate of fullterm infants' characteristic response in the mobile conjugate reinforcement paradigm.

The conjugate reinforcement paradigm did seem to be sensitive to group differences, especially with respect to learning. It should therefore be used in the study of learning and memory in preterm infants. A number of changes should be made, however, to tap the wealth of information provided by infants during this task. First of all, rather than provide infants with only two training days, the training period should be lengthened so that infants can reach and maintain a specified learning criterion.

Increasing the number of minutes of reinforcement during each visit might be most practical for the experimenter, but would be too taxing for those infants with a high kick rate. It would therefore be better to increase the number of visits to the infant. This would allow one to compare the speed with which different groups of infants learn the task and study memory effects over 24-hour intervals. It would also provide information regarding infants who under the present procedure failed to meet the learning criterion within two training sessions. Secondly, recent studies (Rovee-Collier, Earley, & Stafford, 1989; Butler & Rovee-Collier, 1989) as well as findings in these experiments point to the need to develop more sensitive measures of visual attention since this may account for differences in infants' ability to remember the operant. Specifically, when infants are looking at the mobile, one should be able to calculate which of the objects as well as what number of objects are being observed. Thirdly, infants in these experiments varied in terms of their ability to meet the task demands without it proving too taxing on their system. Some infants were able to modulate their response, whereas others seemed to be out of control. The latter group produced jerky movements of all limbs and became increasingly excited, to the point that some infants began to cry. One infant dropped from the complication-free preterm group even seemed to be having convulsions. Similar behaviors were reported in preterm infants at 42 (Als, Duffy, and McAnulty, 1988) and 44 weeks postconception (Als & Brazelton, 1981) when they were given the APIB, at 3 and 5 months in a face-to-face paradigm, and at 9 months in the kangaroo-box paradigm (Als & Brazelton, 1981), and are said to reflect the level of behavioral organization reached by the infant, with a more mature system being able to interact with his environment without appearing overly taxed. It might prove interesting to use the conjugate reinforcement task to help differentiate the level of behavioral organization reached by preterm

infants. The performance of infants on this task might also prove useful in predicting later learning difficulties.

Finally, the interval used between the reactivation treatment and the retention test was 24 hours because it has been reported by Fagen and Rovee-Collier (1983) to be an optimal interval after which time 3-month-old fullterm infants were likely to remember (based on the retention ratio) what they had been taught. In this study, Fagen and Rovee-Collier also reported that fullterm infants' retention ratios were greater when infants were tested 72 hours rather than 24 hours after the reactivation treatment. It is possible that the 24-hour interval which is appropriate for fullterm infants is not an optimal interval for preterm infants. A parametric test of other intervals might be done to determine the optimal interval to use with preterm infants. The most sensitive measure of memory, the baseline ratio and not the retention ratio, should be used to assess retention in this parametric study.

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# Appendix A

## Consent Forms and Letter Sent to Pediatricians

Appendix A-1

CONSENT FORM (Experiment 1 and 2)

The purpose of the study is to investigate learning and longterm memory in babies 3 months after their expected date of birth. Specifically we are interested in how quickly babies of this age learn to kick in order to make a mobile move, how long they remember this response, and whether a visual reminder helps to overcome forgettir g 2 weeks after training.

The study is done in the baby's home and will require 3 or 4 visits depending on the baby's group assignment. The first 2 visits will be for training and will take place on two consecutive days. Memory for the response will be tested 14 days after the training visits. The babies who receive a total of 4 visits will receive a 3-minute reminder (watching the experimenter make the mobile move by pulling the ribbon) 24 hours before a 14-day memory test. Total time for the procedure is 15 minutes for the training periods and memory test, and 3 minutes for the reminder. On each visit, two mobile stands, one with and one without a suspended mobile will be carefully fastened to opposite sides of the crib. During the first and last 3 minutes of the training periods and memory test, a ribbon will be looped around the baby's ankle and connected to the stand with no mobile so that leg kicks do not produce mobile movement. In the intervening 9 minutes, one of the following two procedures will be used: 1) the ribbon will be connected from the baby's ankle to the hook from which the mobile is hanging so that kicking will produce mobile movement, or 2) the infant will be removed from the crib by the mother. Responses will be recorded by videotaping the baby in the crib. Videotapes will be viewed only by research assistants for scoring purposes.

I _____, have read the above description of the study of learning and longterm memory in infants and had the study explained to me. I am willing to participate in the study with my baby. I understand it involves videotaping my child

in its crib at home on three / four occasions. I am aware that I am free to withdraw my child from the study at any time.

Date _____ Mother's Signature _____

Signature of Witness _____

Appendix A-2

CONSENT FORM (Experiment 3)

The purpose of this study is to compare learning and longterm memory in healthy preterm and fullterm babies 3 months after their expected date of birth. Specifically we are interested in how quickly babies learn to kick in order to make a mobile move, and whether seeing this mobile 1 day before a longterm memory test will help them remember what they have learned.

The study is done in the baby's home and will require 4 visits. The first 2 visits will be for training and will take place on two consecutive days. Memory for the response will be tested 14 days after the training visits. The babies will also receive a 3-minute reminder (where the experimenter will make the mobile move for the baby) 24 hours before the 14-day memory test. Total time for the procedure is 15 minutes for the training periods and memory test, and 3 minutes for the reminder. On each visit, a mobile stand will be carefully fastened to one side of the crib. A second mobile will be suspended from a floor stand and placed opposite the first mobile stand. A crib bumper will be placed in the baby's crib so as to make the testing environment the same for all babies. During the first and last 3 minutes of the training periods and memory test, a ribbon will be looped around the baby's ankle and connected to the stand with no mobile so that leg kicks do not produce mobile movement. In the intervening 9 minutes the ribbon will be connected from the baby's ankle to the hook from which the mobile is hanging so that kicking will produce mobile movement. Responses will be recorded by videotaping the baby in the crib. Videotapes will be viewed only by research assistants for scoring purposes.

I _____, have read the above description of the study of learning and longterm memory in infants and had the study explained to me. I am willing to participate in the study with my baby. I understand it involves videotaping my child in

its crib at home on four occasions. I am aware that I am free to withdraw my child from the study at any time.

Date: _____ Mother's Signature: _____

Witness' Signature: _____

Appendix A-3

Letter Sent to Pediatrician

Dear Dr._____,

We are currently investigating learning and longterm memory in 3-month-old infants born at term and in infants of 3 months corrected age born at least 3 weeks prematurely. We would like to include one of your patients as a subject in our study. The purpose of the research is to study the effects of prematurity per se, as well as the effects of certain mild complications associated with prematurity, on learning and memory. An abstract of the study is enclosed.

The research, which is a joint project of members of the Department of Psychology of Concordia University and the Department of Neonatology of the Jewish General Hospital, has been approved by the Ethics and Research Committee of the Jewish General Hospital. Principal investigators are Diane Potvin, M.A., Nancy D. Taylor, Ph.D., and Dr. A Papageorgiou. Subjects are selected from babies born at the Jewish General Hospital. The Ethics and Research Committee has requested that we approach a mother to obtain her consent only after the child's pediatrician has mentioned the study to her and obtained her approval for one of the researchers to contact her. We hope you will be willing to speak to Mrs._____ either by telephone or in the course of an office visit before the following date _____, which is one week before the first visit could take place.

Your cooperation is important to the successful completion of the research project. Any assistance you can provide us would be deeply appreciated. You would, of course, receive a summary of the findings of the study as soon as data collection is complete. I will be calling you in a few weeks to answer any questions and find out if you are willing to help us.

Yours truly,

# Appendix B

## Summary Tables of the Analyses of Infant and Parental Characteristics for Experiments 1, 2, and 3

Table B-1

Analysis of Variance Source Tables of Experiment 1 Infant Characteristics

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Birthweight | 694830.2 | 2 | 347415.1 | 1.9 |
| Error | 4969624.6 | 27 | 184060.2 | |
| GA | 56.9 | 2 | 28.4 | 0.5 |
| Error | 1426.5 | 27 | 52.8 | |
| 1-min Apgar | 0.9 | 2 | 0.4 | 0.8 |
| Error | 14.1 | 27 | 0.5 | |
| 5-min Apgar | 0.3 | 2 | 0.1 | 0.7 |
| Error | 5.1 | 27 | 0.2 | |
| Chronological Age | 24.5 | 2 | 12.2 | 0.3 |
| Error | 1151.4 | 27 | 42.6 | |
| Corrected Age | 94.5 | 2 | 47.2 | 3.0 |
| Error | 418.5 | 27 | 15.5 | |

Table B-2

Analysis of Variance Source Tables of Experiment 1 Parental Characteristics

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Maternal Age | 6.7 | 2 | 3.3 | 0.3 |
| Error | 284.8 | 27 | 10.5 | |
| Paternal Age | 8.5 | 2 | 4.2 | 0.2 |
| Error | 496.9 | 27 | 18.4 | |
| Maternal Education | 31.3 | 2 | 15.6 | 1.9 |
| Error | 223.7 | 27 | 8.3 | |
| Paternal Education | 20.6 | 2 | 10.3 | 1.1 |
| Error | 248.2 | 27 | 9.2 | |

Table B-3

Summary Table of Kruskal-Wallis One-Way Analysis of Variance Experiment 1 Social Class

| Group | Rank Sum | df | H | p |
|---|---|---|---|---|
| No Reactivation | 117.5 | | | |
| Reactivation | 168.5 | | | |
| Familiarization | 179.0 | 2 | 3.2 | 0.2 |

Table B-4

Analysis of Variance Source Tables of Experiment 2 Infant Characteristics

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Birthweight | 287178.9 | 2 | 143589.4 | 1.6 |
| Error | 1707564.6 | 19 | 89871.8 | |
| GA | 10.7 | 2 | 5.4 | 0.2 |
| Error | 728.9 | 21 | 34.7 | |
| 1-min Apgar | 0.7 | 2 | 0.4 | 0.8 |
| Error | 9.9 | 21 | 0.5 | |
| 5-min Apgar | 1.0 | 2 | 0.5 | 2.4 |
| Error | 4.7 | 21 | 0.2 | |
| Chronological Age | 17.6 | 2 | 8.8 | 0.2 |
| Error | 976.4 | 21 | 46.5 | |
| Corrected Age | 30.3 | 2 | 15.2 | 0.5 |
| Error | 639.0 | 21 | 30.4 | |

Table B-5

Analysis of Variance Source Tables of Experiment 2 Parental Characteristics

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Maternal Age | 0.6 | 2 | 0.3 | 0.0 |
| Error | 519.4 | 21 | 24.7 | |
| Paternal Age | 30.3 | 2 | 15.2 | 0.7 |
| Error | 451.0 | 21 | 21.5 | |
| Maternal Education | 13.6 | 2 | 6.8 | 0.7 |
| Error | 202.2 | 21 | 9.6 | |
| Paternal Education | 45.1 | 2 | 22.5 | 1.6 |
| Error | 286.2 | 21 | 13.6 | |

Table B-6

Summary Table of Kruskal-Wallis One-Way Analysis of Variance Experiment 2 Social Class

| Group | Rank Sum | df | H | p |
|---|---|---|---|---|
| No Reactivation | 118.0 | | | |
| Reactivation | 115.5 | | | |
| Familiarization | 66.5 | 2 | 4.7 | 0.1 |

Table B-7

Analysis of Variance Source Tables for Experiment 3 Infant Characteristics

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Birthweight | 13760476.0 | 3 | 4586825.2 | 63.6*** |
| Error | 2090642.5 | 29 | 72091.1 | |
| GA | 10418.9 | 3 | 3472.9 | 81.8*** |
| Error | 1230.8 | 29 | 42.4 | |
| 1-min Apgar | 1.4 | 3 | 0.5 | 1.7 |
| Error | 8.1 | 29 | 0.3 | |
| 5-min Apgar | 0.08 | 3 | 0.03 | 0.1 |
| Error | 5.8 | 29 | 0.2 | |
| Days in Hospital | 597.8 | 3 | 199.3 | 10.6*** |
| Error | 544.5 | 29 | 18.8 | |

continuned on next page...

Table B-7 (continued)

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Lowest Blood Sugar | 10.8 | 2 | 5.4 | 4.5* |
| Error | 23.9 | 20 | 1.2 | |
| Highest Bilirubin | 6790.8 | 2 | 3395.4 | 1.0 |
| Error | 66031.7 | 20 | 3301.6 | |
| Postnatal Complications | 18291.7 | 3 | 6097.2 | 20.9*** |
| Error | 8422.9 | 29 | 290.4 | |
| Obstetric Complications | 4105.6 | 3 | 1368.5 | 6.5** |
| Error | 6091.1 | 29 | 210.0 | |

* $p < .025$. ** $p < .01$. *** $p < .001$.

Table B-8

Analysis of Variance Source Tables of Experiment 3 Parental Characteristics

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Maternal Age | 108.2 | 3 | 36.1 | 2.5 |
| Error | 414.0 | 29 | 14.3 | |
| Paternal Age | 18.4 | 3 | 6.1 | 0.2 |
| Error | 764.5 | 29 | 26.4 | |
| Maternal Education | 47.6 | 3 | 15.9 | 1.7 |
| Error | 267.9 | 29 | 9.2 | |
| Paternal Education | 44.8 | 3 | 14.9 | 0.9 |
| Error | 470.1 | 29 | 16.2 | |

Table B-9

Summary Table of Kruskal-Wallis One-Way Analysis of Variance Experiment 3 Social Class

| Group | Rank Sum | df | H | p |
|---|---|---|---|---|
| Fullterm | 191.0 | | | |
| Compl-Free Preterm | 134.0 | | | |
| Hypoglycemic Preterm | 138.0 | | | |
| Resp Compl Preterm | 98.0 | 3 | 2.56 | 0.5 |

Table B-10

Characteristics of Complication-Free Preterm Infants

| BW | GA | LS | HB | Complications | Learn |
|---|---|---|---|---|---|
| 1880 | 246 | 39.6 | 3.5 | | Day 1 |
| 1970 | 238 | 41.4 | 12.7 | | Day 1 |
| 2080 | 252 | 37.8 | - | | Day 1 |
| 2100 | 249 | 63.1 | 10.4 | | Day 2 |
| 2170 | 224 | 41.4 | 14.7 | | Day 1 |
| 2300 | 240 | 95.5 | 9.5 | | Day 2 |
| 2380 | 240 | - | 11.3 | | Day 1 |
| 2400 | 252 | 36.0 | 13.7 | | Day 2 |
| 2430 | 245 | 63.1 | 13.1 | | Day 2 |
| 2550 | 247 | - | 11.9 | | Day 1 |

BW Birthweight

GA Gestational Age

LS Lowest Blood Sugar Value

HB Highest Bilirubin Count

Table B-11

Characterisitcs of Respiratory Complications Preterm Infants

| BW | GA | LS | HB | Complications | Learn |
|---|---|---|---|---|---|
| 1850 | 238 | 39.6 | 9.1 | mild retractions<br>hypocalcemia | No |
| 2090 | 243 | 54.1 | 11.4 | mild retractions<br>nasal flaring | Day 1 |
| 2260 | 252 | 52.3 | 12.3 | TTN - grunting | Day 2 |
| 2290 | 237 | 37.8 | 14.3 | mild nasal flaring<br>hypocalcemia | No |
| 2670 | 244 | 52.3 | 10.6 | RDS - grunting<br>retractions<br>nasal flaring<br>hypocalcemia | Day 1 |

BW Birthweight

GA Gestational Age

LS Lowest Blood Sugar Value

HB Highest Bilirubin Count

Table B-12

Characteristics of Hypoglycemic Preterm Infants

| BW | GA | LS | HB | Complications | Learn |
|---|---|---|---|---|---|
| 1880 | 233 | 21.6 | 9.8 | | Day 1 |
| 1940 | 233 | 7.2 | 7.8 | PROM | Day 1 |
| 2130 | 251 | 18.0 | 9.7 | | No |
| 2200 | 231 | 23.4 | 12.0 | | Day 1 |
| 2250 | 236 | 19.8 | 11.9 | | Day 1 |
| 2260 | 227 | 21.6 | 10.8 | PROM | Day 1 |
| 2260 | 241 | 19.8 | 10.9 | | Day 1 |
| 2600 | 239 | 12.6 | 12.1 | | Day 1 |
| Hypoglycemic Preterm Infants With One Other Complication | | | | | |
| 2100 | 240 | 23.4 | 12.0 | C-Section Bleeding | Day 1 |
| 2570 | 252 | 25.2 | 15.4 | Hyperbilirubinemia | No |
| 2215 | 224 | 28.8 | 10.7 | C-Section retractions hypocalcemia | Day 1 |

BW Birthweight

GA Gestational Age

LS Lowest Blood Sugar Value

HB Highest Bilirubin Count

PROM Premature Rupture of Membranes

## Appendix C

Summary Tables for Analyses of Environmental Conditions in Experiment 1, 2 and 3

Table C-1

Experiment 1 Analysis of Variance Source Tables for Humidity on Days 1, 2, and 16

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Day 1 | | | | |
| Group | 87.20 | 2 | 43.60 | 0.92 |
| Error | 1272.00 | 27 | 47.11 | |
| Day 2 | | | | |
| Group | 74.47 | 2 | 37.23 | 0.77 |
| Error | 1303.00 | 27 | 48.26 | |
| Day 16 | | | | |
| Group | 60.00 | 2 | 30.00 | 0.69 |
| Error | 1162.70 | 27 | 43.06 | |

Table C-2

Experiment 1 Analysis of Variance Source Tables for Temperature on Days 1, 2, and 16

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Day 1 | | | | |
| Group | 0.47 | 2 | 0.23 | 0.06 |
| Error | 109.40 | 27 | 4.05 | |
| Day 2 | | | | |
| Group | 0.07 | 2 | 0.03 | 0.01 |
| Error | 89.40 | 27 | 3.31 | |
| Day 16 | | | | |
| Group | 10.40 | 2 | 5.20 | 1.51 |
| Error | 92.80 | 27 | 3.44 | |

Table C-3

Experiment 2 Analysis of Variance Source Tables for Humidity on Days 1, 2, and 16

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Day 1 | | | | |
| Group | 154.75 | 2 | 77.37 | 1.76 |
| Error | 919.75 | 21 | 43.79 | |
| Day 2 | | | | |
| Group | 166.08 | 2 | 83.04 | 2.49 |
| Error | 697.87 | 21 | 33.23 | |
| Day 16 | | | | |
| Group | 13.00 | 2 | 6.50 | 0.04 |
| Error | 3431.62 | 21 | 163.41 | |

Table C-4

Experiment 2 Analysis of Variance Source Tables for Temperature on Days 1, 2, and 16

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Day 1 | | | | |
| Group | 1.75 | 2 | 0.87 | 0.11 |
| Error | 162.75 | 21 | 7.75 | |
| Day 2 | | | | |
| Group | 14.58 | 2 | 7.29 | 0.84 |
| Error | 183.25 | 21 | 8.73 | |
| Day 16 | | | | |
| Group | 16.08 | 2 | 8.04 | 0.68 |
| Error | 249.25 | 21 | 11.87 | |

Table C-5

Experiment 3 Analysis of Variance Source Tables for Humidity on Days 1, 2, 15, and 16

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Day 1 | | | | |
| Group | 42.06 | 3 | 14.02 | 0.33 |
| Error | 1244.00 | 29 | 42.89 | |
| Day 2 | | | | |
| Group | 91.11 | 3 | 30.37 | 0.69 |
| Error | 1272.4 | 29 | 43.87 | |
| Day 15 | | | | |
| Group | 231.07 | 3 | 77.02 | 0.98 |
| Error | 2271.17 | 29 | 78.31 | |
| Day 16 | | | | |
| Group | 52.91 | 3 | 17.64 | 0.32 |
| Error | 1619.27 | 29 | 55.84 | |

Table C-6

Experiment 3 Analysis of Variance Source Tables for Temperature on Days 1, 2, 15 and 16

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Day 1 | | | | |
| Group | 11.74 | 3 | 3.91 | 0.52 |
| Error | 218.80 | 29 | 7.54 | |
| Day 2 | | | | |
| Group | 9.01 | 3 | 3.00 | 0.36 |
| Error | 239.17 | 29 | 8.24 | |
| Day 15 | | | | |
| Group | 36.13 | 3 | 12.04 | 2.09 |
| Error | 167.20 | 29 | 5.77 | |
| Day 16 | | | | |
| Group | 20.39 | 3 | 6.79 | 0.95 |
| Error | 206.57 | 29 | 7.12 | |

# Appendix D

## Summary Tables for Analyses of Experiment 1 Footkick Data During Acquisition

Table D-1

Mean Footkick Data for the Reactivation, No Reactivation, and No Training Groups Days 1, 2, and 16

| | React | No React | No Training |
|---|---|---|---|
| Day 1 | | | |
| Block 1 | 13.6 | 7.3 | 13.2 |
| Block 2 | 19.6 | 9.4 | |
| Block 3 | 25.1 | 17.8 | |
| Block4 | 29.9 | 17.7 | |
| Block 5 | 28.9 | 15.0 | 13.7 |
| Day 2 | | | |
| Block 1 | 16.1 | 11.1 | 8.6 |
| Block 2 | 21.0 | 11.9 | |
| Block 3 | 20.8 | 18.8 | |
| Block4 | 24.9 | 19.0 | |
| Block 5 | 23.0 | 20.1 | 18.8 |
| Day 16 | | | |
| Block 1 | 13.8 | 8.5 | 9.5 |
| Block 2 | 15.8 | 11.0 | 10.1 |
| Block 3 | 20.1 | 18.0 | 12.2 |
| Block4 | 20.5 | 16.3 | 11.8 |
| Block 5 | 21.3 | 17.8 | 17.6 |

Table D-2

Levene's Test of Homogeneity of Variance on the Day 1 and 2 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 17.5 | 1 | 17.5 | 3.4 |
| Error | 93.5 | 18 | 5.2 | |
| Day | 0.0 | 1 | 0.0 | 0.0 |
| GXD | 0.9 | 1 | 0.9 | 0.6 |
| Error | 27.9 | 18 | 1.5 | |
| Block | 0.0 | 4 | 0.0 | 0.0 |
| GXB | 1.7 | 4 | 0.4 | 1.1 |
| Error | 28.6 | 72 | 0.4 | |
| DXB | 0.0 | 4 | 0.0 | 0.0 |
| GXDXB | 0.2 | 4 | 0.1 | 0.2 |
| Error | 19.5 | 72 | 0.3 | |

Table D-3

Analysis of Variance Source Table for the Initial Three Minutes of Kicking

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Groups | 729.7 | 2 | 364.8 | 1.9 |
| Error | 5179.7 | 27 | 191.8 | |
| Minute | 497.1 | 2 | 248.5 | 4.3* |
| Error | 3148.8 | 54 | 58.3 | |
| GXM | 132.1 | 4 | 33.0 | 0.6 |
| Error | 3148.8 | 54 | 58.3 | |

* $p < .025$.

Table D-4

Analysis of Variance Source Table for the Day 1 and 2 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Groups | 2731.3 | 1 | 2731.3 | 3.1 |
| Error | 15790.9 | 18 | 877.3 | |
| Day | 1.2 | 1 | 1.2 | 0.0 |
| GXD | 290.2 | 1 | 290.2 | 1.2 |
| Error | 4357.1 | 18 | 242.1 | |
| Blocks | 3360.2 | 4 | 840.0 | 10.6* |
| GXB | 173.6 | 4 | 43.4 | 0.5 |
| Error | 5683.7 | 72 | 78.9 | |
| DXB | 183.1 | 4 | 45.8 | 1.2 |
| GXDXB | 187.6 | 4 | 46.9 | 1.2 |
| Error | 2808.1 | 72 | 39.0 | |

* $p < 001$.

Table D-5

Analysis of Variance Source Table for the No Training Group's Footkick Data Across Training Days

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Day | 0.0 | 1 | 0.0 | 0.0 |
| Error | 370.6 | 9 | 41.2 | |
| Block | 304.7 | 1 | 304.7 | 4.1 |
| Error | 662.4 | 9 | 73.6 | |
| DXB | 225.6 | 1 | 225.6 | 11.3* |
| Error | 179.3 | 9 | 19.9 | |

* $p < .01$.

Table D-6

Analysis of Variance Source Tables of the 24-Hour Baseline and Retention Ratios of the No Reactivation, Reactivation, and No Training Groups

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| 24-Hour Baseline Ratio | | | | | |
| Groups | 6.9 | 2 | 3.4 | 2.9 | 0.1 |
| Error | 32.0 | 27 | 1.2 | | |
| 24-Hour Retention Ratio | | | | | |
| Groups | 0.3 | 2 | 0.1 | 0.3 | 0.7 |
| Error | 12.1 | 26 | 0.5 | | |

Table D-7

T-Tests Comparing the 24-Hour Baseline and Retention Ratios of the No Reactivation, Reactivation, and No Training Control Groups in Study 1 to a Theoretical Value of 1.0

| Group | T-Test Score |
|---|---|
| 24-Hour Baseline Ratio | |
| No Reactivation | $t(9) = 2.87$ ** |
| Reactivation | $t(9) = 0.97$ |
| No Training | $t(9) = 1.89$* |
| 24-Hour Retention Ratio | |
| No Reactivation | $t(9) = 1.41$ |
| Reactivation | $t(9) = 0.45$ |
| No Training | $t(9) = 0.23$ |

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

# Appendix E

## Summary Tables for Analyses of Experiment 1 Day 16 Footkick Data

Table E-1

Levene's Test of Homogeneity of Variance on the Day 16 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 8.3 | 2 | 4.2 | 1.1 |
| Error | 96.8 | 27 | 3.6 | |
| Block | 0.0 | 4 | 0.0 | 0.0 |
| GXB | 2.4 | 8 | 0.3 | 0.8 |
| Error | 37.5 | 108 | 0.3 | |

Table E-2

Analysis of Variance Source Table for Day 16 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 864.6 | 2 | 432.3 | 1.0 |
| Error | 12032.9 | 27 | 445.7 | |
| Block | 1303.5 | 4 | 325.9 | 7.1* |
| GXB | 231.9 | 8 | 28.9 | 0.6 |
| Error | 4973.5 | 108 | 46.0 | |

* $p < .001$.

Table E-3

Analysis of Variance Source Tables of the 2-Week Baseline and Retention Ratios of the No Reactivation, Reactivation, and No Training Groups

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| 2-Week Baseline Ratio | | | | | |
| Groups | 3.49 | 2 | 1.7 | 1.5 | 0.2 |
| Error | 31.0 | 27 | 1.1 | | |
| 2-Week Retention Ratio | | | | | |
| Groups | 0.1 | 2 | 0.1 | 0.4 | 0.7 |
| Error | 4.6 | 27 | 0.2 | | |

Table E-4

T-Tests Comparing the 2-Week Baseline and Retention Ratios of the No Reactivation, Reactivation, and No Training Groups in Study 1 to a Theoretical Value of 1.0

| Group | t-Test Score |
|---|---|
| 2-Week Baseline Ratio | |
| No Reactivation | $t(9) = 1.42$ |
| Reactivation | $t(9) = 0.97$ |
| No Training | $t(9) = 1.89$ |
| 2-Week Retention Ratio | |
| No Reactivation | $t(9) = 4.40$ ** |
| Reactivation | $t(9) = 4.00$ ** |
| No Training | $t(9) = 2.13$ * |

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

Table E-5

Analysis of Variance Source Table for First Training Day of the Reactivation, No Reactivation, and No Training Groups

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 3706.4 | 2 | 1853.2 | 3.2 |
| Error | 15544.8 | 27 | 575.7 | |
| Block | 2422.5 | 4 | 605.6 | 11.1* |
| GXB | 714.7 | 8 | 89.3 | 1.6 |
| Error | 5913.8 | 108 | 54.8 | |

* $p < .001$.

# Appendix F

## Summary Tables for Analyses of the Experiment 1 Visual Attention Data

Table F-1

Levene's Test of Homogeneity of Variance for the Day 1 and 2 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 2.1 | 1 | 2.1 | .8 |
| Error | 49.4 | 18 | 2.7 | |
| Day | 0.0 | 1 | 0.0 | 0.0 |
| GXD | 0.2 | 1 | 0.2 | 0.3 |
| Error | 14.9 | 18 | 0.8 | |
| Phase | 0.0 | 2 | 0.0 | 0.0 |
| GXP | 0.4 | 2 | 0.2 | 0.3 |
| Error | 21.3 | 36 | 0.6 | |
| DXP | 0.0 | 2 | 0.0 | 0.0 |
| GXDXP | 3.5 | 2 | 1.8 | 2.9 |
| Error | 22.1 | 36 | 0.6 | |

Table F-2

Analysis of Variance Source Table for the Day 1 and 2 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 559.9 | 1 | 559.9 | 1.1 |
| Error | 9028.3 | 18 | 501.6 | |
| Day | 22.2 | 1 | 22.2 | 0.1 |
| GXD | 40.4 | 1 | 40.4 | 0.2 |
| Error | 3119.8 | 18 | 173.3 | |
| Phase | 1432.9 | 2 | 716.5 | 6.1** |
| GXP | 178.9 | 2 | 89.5 | 0.8 |
| Error | 4260.0 | 36 | 118.3 | |
| DXP | 244.5 | 2 | 122.2 | 0.8 |
| GXDXP | 1137.7 | 2 | 568.8 | 3.8* |
| Error | 5347.3 | 36 | 148.5 | |

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

Table F-3

Analysis of Variance Source Table of Days 1 and 2 Visual Attention Data for the No Training Control Group

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Day | 270.4 | 1 | 270.4 | 3.0 |
| Error | 799.6 | 9 | 88.8 | |
| Phase | 4.9 | 1 | 4.9 | 0.1 |
| Error | 991.1 | 9 | 110.1 | |
| Visit X Phase | 0.1 | 1 | 0.1 | 0.0 |
| Error | 797.9 | 9 | 88.7 | |

Table F-4

Analysis of Variance Source Table for the Visual Attention Data During the Reactivation Treatment

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 0.0 | 1 | 0.0 | 0.0 |
| Error | 3491.9 | 18 | 194.0 | |

Table F-5

Levene's Test of Homogeneity of Variance for the Day 16 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 0.7 | 2 | 0.4 | 0.2 |
| Error | 54.9 | 27 | 2.0 | |
| Phase | 0.0 | 2 | 0.0 | 0.0 |
| GXP | 2.2 | 4 | 0.5 | 1.0 |
| Error | 29.1 | 54 | 0.5 | |

Table F-6

Analysis of Variance Source Table of Day 16 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 258.5 | 2 | 129.3 | 0.3 |
| Error | 10794.4 | 27 | 399.8 | |
| Phase | 2280.9 | 2 | 1140.4 | 9.3 * |
| Phase X Group | 534.7 | 4 | 133.7 | 1.1 |
| Error | 6648.5 | 54 | 123.1 | |

* $p < .001$

# Appendix G

## Summary Tables for Analyses of Experiment 2 Footkick Data During Acquisition

Table G-1

Mean Footkick Data for the Reactivation, No Reactivation, and No Training Groups Days 1, 2, and 16

| | React | No React | No Training |
|---|---|---|---|
| Day 1 | | | |
| Block 1 | 8.4 | 11.2 | 10.1 |
| Block 2 | 10.0 | 14.3 | |
| Block 3 | 11.4 | 16.4 | |
| Block4 | 10.5 | 18.9 | |
| Block 5 | 14.2 | 25.1 | 13.2 |
| Day 2 | | | |
| Block 1 | 13.6 | 12.4 | 11.2 |
| Block 2 | 14.2 | 19.0 | |
| Block 3 | 15.3 | 21.5 | |
| Block4 | 14.7 | 16.2 | |
| Block 5 | 18.5 | 23.4 | 13.8 |
| Day 16 | | | |
| Block 1 | 12.0 | 9.6 | 9.2 |
| Block 2 | 13.7 | 14.5 | 14.8 |
| Block 3 | 18.1 | 14.9 | 15.3 |
| Block4 | 13.3 | 13.9 | 12.1 |
| Block 5 | 13.2 | 19.5 | 12.03 |

Table G-2

Levene's Test of Homogeneity of Variance on the Day 1 and 2 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 10.3 | 1 | 10.3 | 1.8 |
| Error | 80.4 | 14 | 5.7 | |
| Day | 0.0 | 1 | 0.0 | 0.0 |
| GXD | 1.4 | 1 | 1.4 | 2.5 |
| Error | 7.8 | 14 | 0.6 | |
| Block | 0.0 | 4 | 0.0 | 0.0 |
| GXB | 1.5 | 4 | 0.4 | 0.7 |
| Error | 27.6 | 56 | 0.5 | |
| DXB | 0.0 | 4 | 0.0 | 0.0 |
| GXDXB | 0.6 | 4 | 0.2 | 0.4 |
| Error | 20.4 | 56 | 0.4 | |

Table G-3

Analysis of Variance Source Table for the Mean Number of Kicks in the Initial Three Minutes

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 92.1 | 2 | 46.0 | 0.3 |
| Error | 2783.9 | 21 | 132.6 | |
| Minute | 94.8 | 2 | 47.4 | 2.9 |
| GXM | 24.4 | 4 | 6.1 | 0.4 |
| Error | 677.5 | 42 | 16.1 | |

Table G-4

Analysis of Variance Source Table for the Reactivation and No Reactivation Groups' Day 1 and 2 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 902.9 | 1 | 902.9 | 1.7 |
| Error | 7524.9 | 14 | 537.5 | |
| Day | 321.8 | 1 | 321.8 | 6.1* |
| GXD | 93.2 | 1 | 93.2 | 1.8 |
| Error | 742.2 | 14 | 53.0 | |
| Block | 1330.3 | 4 | 332.6 | 5.7** |
| GXB | 212.1 | 4 | 53.0 | 0.9 |
| Error | 3259.4 | 56 | 58.2 | |
| DXB | 99.0 | 4 | 24.8 | 0.7 |
| GXDXB | 108.3 | 4 | 27.1 | 0.7 |
| Error | 2062.8 | 56 | 36.8 | |

* $p < .05$. ** $p < .001$.

Table G-5

Analysis of Variance Source Table for the No Training Group's Day 1 and 2 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Day | 5.6 | 1 | 5.6 | 1.2 |
| Error | 223.7 | 7 | 31.9 | |
| Block | 63.8 | 1 | 63.8 | 3.7 |
| Error | 121.8 | 7 | 17.4 | |
| DXB | 0.7 | 1 | 0.7 | 0.1 |
| Error | 70.6 | 7 | 10.1 | |

Table G-6

Analysis of Variance Source Tables of the 24-Hour Baseline and Retention Ratios of the No Reactivation, Reactivation, and No Training Groups

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| 24-Hour Baseline Ratio | | | | | |
| Groups | 17.1 | 2 | 8.6 | 0.7 | 0.5 |
| Error | 253.2 | 21 | 12.1 | | |
| 24-Hour Retention Ratio | | | | | |
| Groups | 0.7 | 2 | 0.3 | 1.0 | 0.4 |
| Error | 7.2 | 21 | 0.3 | | |

Table G-7

T-Tests Comparing the 24-Hour Baseline and Retention Ratios of the No Reactivation, Reactivation, and No Training Control Groups to a Theoretical Value of 1.0

| Group | t-Test Score |
|---|---|
| 24-Hour Baseline Ratio | |
| No Reactivation | $t(7) = 1.3$ |
| Reactivation | $t(7) = 1.0$ |
| No Training | $t(7) = 0.4$ |
| 24-Hour Retention Ratio | |
| No Reactivation | $t(7) = 2.6^{*}$ |
| Reactivation | $t(7) = 0.4$ |
| No Training | $t(7) = 0.1$ |
| 24-Hour Savings Ratio | |
| No Reactivation | $t(7) = 1.5$ |
| Reactivation | $t(7) = 3.9^{**}$ |

* $p < .025$. ** $p < .005$.

# Appendix H

## Summary Tables for Analyses of Experiment 2 Day 16 Footkick Data

Table H-1

Levene's Test of Homogeneity of Variance on the Day 16 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 1.0 | 2 | 0.5 | 0.2 |
| Error | 65.0 | 21 | 3.1 | |
| | | | | |
| Block | 0.0 | 4 | 0.0 | 0.0 |
| GXB | 3.8 | 8 | 0.5 | 0.9 |
| Error | 45.2 | 84 | 0.5 | |

Table H-2

Analysis of Variance Source Table for Day 16 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 70.2 | 2 | 35.1 | 0.2 |
| Error | 4244.2 | 21 | 202.1 | |
| Block | 471.3 | 4 | 117.8 | 3.2* |
| GXB | 293.6 | 8 | 36.7 | 1.0 |
| Error | 3092.0 | 84 | 36.8 | |

* $p < .025$.

Table H-3

Analysis of Variance Source Tables for the 2-Week Baseline, Retention, and Savings Ratios

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| 2-Week Baseline Ratio | | | | | |
| Group | 2.3 | 2 | 1.2 | 1.0 | |
| Error | 24.4 | 21 | 1.2 | | |
| 2-Week Retention Ratio | | | | | |
| Group | 0.9 | 2 | 0.4 | 1.4 | |
| Error | 6.2 | 21 | 0.3 | | |
| 2-Week Savings Ratio | | | | | |
| Group | 1.1 | 1 | 1.1 | 2.4 | |
| Error | 6.0 | 14 | 0.4 | | |

Table H-4

T-Tests Comparing the 2-Week Baseline and Retention Ratios of the No Reactivation, Reactivation, and No Training Groups to a Theoretical Value of 1.0

| Group | T-Test Score |
|---|---|
| 2-Week Baseline Ratio | |
| No Reactivation | $t(7) = 0.4$ |
| Reactivation | $t(7) = 2.2$ * |
| No Training | $t(7) = 0.3$ |
| 2-Week Retention Ratio | |
| No Reactivation | $t(7) = 6.0$ ** |
| Reactivation | $t(7) = 0.6$ |
| No Training | $t(7) = 0.7$ |
| 2-Week Savings Ratio | |
| No Reactivation | $t(7) = 0.3$ |
| Reactivation | $t(7) = 1.55$ |

* $p < .05$. ** $p < .001$.

Table H-5

Analysis of Variance Source Table for First Training Day of the Reactivation, No Reactivation, and No Training Groups

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 837.7 | 2 | 418.9 | 2.0 |
| Error | 4444.2 | 21 | 211.6 | |
| Block | 706.8 | 4 | 176.7 | 6.9** |
| GXB | 527.7 | 4 | 66.0 | 2.6* |
| Error | 2160.6 | 84 | 25.7 | |

* $p < .01$. ** $p < .001$.

# Appendix I

## Summary Tables for Analyses of Experiment 2 Visual Attention Data

Table I-1

Levene's Test of Homogeneity of Variance for the Day 1 and 2 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 0.9 | 1 | 0.9 | .6 |
| Error | 22.8 | 14 | 1.6 | |
| Day | 0.0 | 1 | 0.0 | 0.0 |
| GXD | 2.8 | 1 | 2.8 | 2.3 |
| Error | 16.7 | 14 | 1.2 | |
| Phase | 0.0 | 2 | 0.0 | 0.0 |
| GXP | 0.5 | 2 | 0.2 | 0.4 |
| Error | 18.5 | 28 | 0.7 | |
| DXP | 0.0 | 2 | 0.0 | 0.0 |
| GXDXP | 2.5 | 2 | 1.2 | 1.4 |
| Error | 25.2 | 28 | 0.9 | |

Table I-2

Analysis of Variance Source Table for the Day 1 and 2 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 60.8 | 1 | 60.8 | 0.6 |
| Error | 1503.3 | 14 | 107.4 | |
| Day | 128.3 | 1 | 128.3 | 1.5 |
| GXD | 32.2 | 1 | 32.2 | 0.4 |
| Error | 1183.4 | 14 | 84.5 | |
| Phase | 469.7 | 2 | 234.8 | 4.6* |
| GXP | 63.0 | 2 | 31.5 | 0.6 |
| Error | 1414.5 | 28 | 50.5 | |
| DXP | 10.4 | 2 | 5.2 | 0.1 |
| GXDXP | 128.0 | 2 | 64.0 | 1.1 |
| Error | 1610.0 | 28 | 57.5 | |

* $p < .02$.

Table I-3

Analysis of Variance Source Table of Days 1 and 2 Visual Attention Data for the No Training Control Group

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Day | 11.2 | 1 | 11.2 | 0.2 |
| Error | 413.9 | 7 | 59.1 | |
| Phase | 4.6 | 1 | 4.6 | 0.5 |
| Error | 63.5 | 7 | 9.1 | |
| Visit X Phase | 17.0 | 1 | 17.0 | 2.9 |
| Error | 40.9 | 7 | 5.8 | |

Table I-4

Analysis of Variance Source Table for the Visual Attention Data During the Reactivation Treatment

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 386.1 | 1 | 386.1 | 1.6 |
| Error | 3283.7 | 14 | 234.5 | |

Table I-5

Levene's Test of Homogeneity of Variance for the Day 16 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 4.6 | 2 | 2.3 | 1.1 |
| Error | 43.8 | 21 | 2.1 | |
| Phase | 0.0 | 2 | 0.0 | 0.0 |
| GXP | 2.7 | 4 | 0.7 | 1.6 |
| Error | 17.9 | 42 | 0.4 | |

Table I-6

Analysis of Variance Source Table of Day 16 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 339.6 | 2 | 169.8 | 1.3 |
| Error | 2747.4 | 21 | 130.8 | |
| Phase | 1515.0 | 2 | 757.5 | 15.2 * |
| Phase X Group | 328.1 | 4 | 82.0 | 1.6 |
| Error | 2094.7 | 42 | 49.9 | |

* $p < .001$

# Appendix J

## Summary Tables of Analyses for Experiment 3 Day 1 and 2 Footkick Data

Table J-1

Mean Footkick Data for the Complication-Free, Hypoglycemic, and Respiratory Complications Preterm and Fullterm Groups Days 1, 2, and 16

| | FT | Compl Free | Hypoglycemic | Resp Compl |
|---|---|---|---|---|
| Day 1 | | | | |
| Block 1 | 11.0 | 12.7 | 9.7 | 13.5 |
| Block 2 | 10.7 | 16.6 | 12.6 | 11.5 |
| Block 3 | 13.8 | 18.9 | 15.1 | 12.9 |
| Block4 | 15.2 | 20.2 | 12.9 | 13.3 |
| Block 5 | 20.7 | 25.1 | 20.9 | 14.6 |
| Day 2 | | | | |
| Block 1 | 10.5 | 17.5 | 12.3 | 9.1 |
| Block 2 | 13.9 | 14.4 | 13.2 | 8.9 |
| Block 3 | 18.9 | 15.2 | 14.6 | 13.3 |
| Block4 | 18.2 | 16.0 | 15.9 | 13.8 |
| Block 5 | 19.8 | 21.3 | 17.6 | 15.1 |
| Day 16 | | | | |
| Block 1 | 11.3 | 13.1 | 9.6 | 15.13 |
| Block 2 | 8.4 | 16.8 | 12.8 | 13.3 |
| Block 3 | 11.2 | 17.8 | 14.8 | 23.6 |
| Block4 | 12.2 | 20.6 | 12.9 | 22.3 |
| Block 5 | 14.6 | 20.2 | 10.8 | 24.7 |

Table J-2

Levene's Test of Homogeneity of Variance on the Day 1 and 2 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 8.5 | 3 | 2.8 | 0.4 |
| Error | 195.8 | 29 | 6.7 | |
| Day | 0.0 | 1 | 0.0 | 0.0 |
| GXD | 2.6 | 3 | 0.9 | 0.7 |
| Error | 36.4 | 29 | 1.2 | |
| Block | 0.0 | 4 | 0.0 | 0.0 |
| GXB | 2.5 | 12 | 0.2 | 0.5 |
| Error | 46.9 | 116 | 0.4 | |
| DXB | 0.1 | 4 | 0.01 | 0.1 |
| GXDXB | 3.8 | 12 | 0.3 | 1.6 |
| Error | 23.4 | 116 | 0.2 | |

Table J-3

Analysis of Variance Source Table for the Mean Number of Kicks in the Initial Three Minutes

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 219.5 | 3 | 73.2 | 0.3 |
| Error | 7192.4 | 29 | 248.0 | |
| Minute | 5.5 | 2 | 2.8 | 0.1 |
| GXM | 166.6 | 6 | 27.8 | 0.6 |
| Error | 2634.6 | 58 | 45.4 | |

Table J-4

Analysis of Variance Source Table for the Groups' Day 1 and 2 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 1042.1 | 3 | 347.4 | 0.4 |
| Error | 23158.9 | 29 | 798.6 | |
| Day | 2.3 | 1 | 2.3 | 0.0 |
| GXD | 282.2 | 3 | 94.1 | 0 6 |
| Error | 4323.7 | 29 | 149.1 | |
| Block | 2343.6 | 4 | 585.9 | 11.4* |
| GXB | 309.8 | 12 | 25.8 | 0.5 |
| Error | 5982.7 | 116 | 51.6 | |
| DXB | 55.6 | 4 | 13.9 | 0.5 |
| GXDXB | 472.5 | 12 | 39.4 | 1.5 |
| Error | 3056.9 | 116 | 26.2 | |

* $p < .05$. ** $p < .001$.

Table J-5

Analysis of Variance Source Tables of the 24-Hour Baseline and Retention Ratios

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| 24-Hour Baseline Ratio | | | | | |
| Groups | 2.2 | 3 | 0.7 | 0.5 | 0.7 |
| Error | 44.8 | 29 | 1.5 | | |
| 24-Hour Retention Ratio | | | | | |
| Groups | 0.6 | 3 | 0.2 | 1.0 | 0.4 |
| Error | 5.7 | 29 | 0.2 | | |
| 24-Hour Savings Ratio | | | | | |
| Groups | 0.5 | 3 | 0.2 | 0.7 | 0.5 |
| Error | 7.0 | 29 | 0.3 | | |

Table J-6

T-Tests Comparing the Groups' 24-Hour Baseline and Retention Ratios to a Theoretical Value of 1.0 and the Savings Ratios to a Theoretical Value of 0

| Group | t-Test Score |
|---|---|
| 24-Hour Baseline Ratio | |
| Fullterm | t(9) = 1.11 |
| Complication-Free Preterm | t(9) = 0.98 |
| Hypoglycemic Preterm | t(7) = 1.29 |
| Respiratory Complications Preterm | t(4) = 0.58 |
| 24-Hour Retention Ratio | |
| Fullterm | t(9) = 7.5 *** |
| Complication-Free Preterm | t(9) = 0.71 |
| Hypoglycemic Preterm | t(7) = 1.10 |
| Respiratory Complications Preterm | t(4) = 2.44 * |
| 24-Hour Savings Ratio | |
| Fullterm | t(9) = 3.0 ** |
| Complication-Free Preterm | t(9) = 1.10 |
| Hypoglycemic Preterm | t(7) = 1.05 |
| Respiratory Complications Preterm | t(4) = 0.14 |

* $p < .05$. ** $p < .01$. *** $p < .001$.

# Appendix K

## Summary Tables for Analyses of Experiment 3 Day 16 Footkick Data

Table K-1

Levene's Test of Homogeneity of Variance on the Day 16 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 9.48 | 3 | 3.16 | 1 06 |
| Error | 77.74 | 26 | 2.99 | |
| | | | | |
| Block | 0.09 | 4 | 0.02 | 0.07 |
| GXB | 2.14 | 12 | 0.18 | 0.60 |
| Error | 31.0 | 104 | 0.29 | |

Table K-2

Analysis of Variance Source Table for Day 16 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 1584.3 | 3 | 528.1 | 1.1 |
| Error | 12839.8 | 26 | 493.8 | |
| Block | 560.4 | 4 | 140.1 | 2.8* |
| GXB | 365.0 | 12 | 30.4 | 0.6 |
| Error | 5137.6 | 104 | 49.4 | |

* $p < .05$.

Table K-3

T-Tests Comparing the 2-Week Baseline and Retention and Savins Ratios to a Theoretical Value

| Group | t-Test Score |
|---|---|
| 2-Week Baseline Ratio | |
| Fullterm | t(9) = 0.59 |
| Complication-Free Preterm | t(9) = 1.21 |
| Hypoglycemic Preterm | t(7) = 0.93 |
| Respiratory Complications Preterm | t(4) = 0.26 |
| 2-Week Retention Ratio | |
| Fullterm | t(9) = 3.70* |
| Complication-Free Preterm | t(9) = 0.67 |
| Hypoglycemic Preterm | t(7) = 1.23 |
| Respiratory Complications Preterm | t(4) = 0.48 |
| 2-Week Savings Ratio | |
| Fullterm | t(9) = 1.44 |
| Complication-Free Preterm | t(9) = 1.27 |
| Hypoglycemic Preterm | t(7) = 1.67 |
| Respiratory Complications Preterm | t(4) = 0.87 |

* $p < .01$.

# Appendix L

## Summary Tables for Analyses of Experiment 3 Visual Attention Data

Table L-1

Levene's Test of Homogeneity of Variance for the Day 1 and 2 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 8.3 | 3 | 2.8 | 1 0 |
| Error | 70.1 | 26 | 2.7 | |
| Day | 0.2 | 1 | 0.2 | 0 7 |
| GXD | 4.2 | 3 | 1.4 | 4.5 * |
| Error | 8.0 | 26 | 0.3 | |
| Phase | 0.1 | 2 | 0.1 | 0.09 |
| GXP | 3.5 | 6 | 0.6 | 0.7 |
| Error | 40.5 | 52 | 0.8 | |
| DXP | 0.1 | 2 | 0.1 | 0.2 |
| GXDXP | 4.3 | 6 | 0.7 | 1.9 |
| Error | 19.5 | 52 | 0.4 | |

Table L-2

Levene's Test of Homogeneity of Variance for the Day 1 and 2 Visual Attention Reciprocal Transformation Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 5.6 | 3 | 1.9 | 0.9 |
| Error | 52.9 | 26 | 2.0 | |
| Day | 0.2 | 1 | 0.2 | 0.7 |
| GXD | 4.0 | 3 | 1.3 | 4.6* |
| Error | 7.6 | 26 | 0.3 | |
| Phase | 0.2 | 2 | 0.1 | 0.1 |
| GXP | 1.4 | 6 | 0.2 | 0.3 |
| Error | 40.9 | 52 | 0.8 | |
| DXP | 0.3 | 6 | 0.1 | 0.2 |
| GXDXP | 7.7 | 6 | 1.3 | 1.7 |
| Error | 38.7 | 52 | 0.7 | |

* $p < .01$.

Table L-3

Analysis of Variance Source Table for the Day 1 and 2 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 818.8 | 3 | 272.9 | 0.9 |
| Error | 8207.6 | 26 | 315.7 | |
| Day | 14.4 | 1 | 14.4 | 0.3 |
| GXD | 694.5 | 3 | 231.5 | 4.3* |
| Error | 1407.0 | 26 | 54.1 | |
| Phase | 658.0 | 2 | 329.0 | 3.0 |
| GXP | 361.8 | 6 | 60.3 | 0.5 |
| Error | 5673.9 | 52 | 109.1 | |
| DXP | 82.2 | 2 | 41.1 | 0.8 |
| GXDXP | 564.7 | 6 | 94.1 | 1.9 |
| Error | 2595.2 | 52 | 49.9 | |

* $p < .01$.

Table L-4

Analysis of Variance Source Table for the Groups' Reactivation Treatment Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Groups | 317.3 | 3 | 105.8 | 1.3 |
| Error | 2399.8 | 29 | 82.7 | |

Table L-5

Levene's Test of Homogeneity of Variance for the Day 16 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 13.6 | 3 | 4.5 | 3.4* |
| Error | 35.0 | 26 | 1.3 | |
| Phase | 0.1 | 2 | 0.1 | 0.1 |
| GXP | 2.5 | 6 | 0.4 | 0.8 |
| Error | 27.0 | 52 | 0.5 | |

* $p < .05$.

Table L-6

Levene's Test of Homogeneity of Variance for the Day 16 Visual Attention Reciprocally Transformed Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 10.7 | 3 | 3.6 | 3.2* |
| Error | 28.5 | 26 | 1.1 | |
| Phase | 0.2 | 2 | 0.1 | 0.2 |
| Phase X Group | 3.5 | 6 | 0.6 | 0.9 |
| Error | 33.3 | 52 | 0.6 | |

* $p < .0.5$.

Table L-7

Analysis of Variance Source Table of Day 16 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 1169.7 | 3 | 389.9 | 2.8 |
| Error | 3566.7 | 26 | 137.2 | |
| Phase | 908.1 | 2 | 454.0 | 6.5* |
| Phase X Group | 297.4 | 6 | 49.6 | 0.7 |
| Error | 3626.4 | 52 | 69.7 | |

* $p < .01$.

Table L-8

Spearman Rank Correlations between Visual Attention and Mean Footkick Data For All Phases of Days 1, 2, and 16

| | Day 1 | | | Day 2 | | | Day 16 | | |
|---|---|---|---|---|---|---|---|---|---|
| | B | R | E | B | R | E | B | R | E |
| CF PT | .39 | .51 | .64 | .50 | .44 | .79** | .05 | .02 | -.20 |
| Hyp PT | .90 | .60 | .33 | .30 | .70 | .40 | .15 | -.30 | .20 |
| Resp Pt | -.40 | .74 | 1.0* | .21 | -.40 | .20 | -.78 | .80 | .40 |
| FT | .14 | .20 | .38 | .22 | .11 | .71* | -.37 | .31 | .05 |
| Exp 1 FT | | | | | | | | | |
| React | -.11 | .27 | .49 | .25 | .70* | .86** | .62 | .11 | .31 |
| No React | .68* | .40 | -.10 | .12 | .56 | .33 | .25 | .32 | .18 |
| Exp 2 FT | | | | | | | | | |
| React | -.12 | -.22 | .57 | .67 | .65 | .52 | -.27 | .17 | .00 |
| No React | -.69 | -.05 | -.29 | .34 | .27 | .27 | -.33 | .26 | .00 |

* $p < .05$. ** $p < .02$.

L-9

Spearman Rank Correlations Between Day 1 Visual Attention in the Reinforcement Phase and 24-Hour Baseline and Retention Ratios and Between Mean Day 1-2 Visual Attention and 2-Week Baseline and Retention Ratios

| | FT | CFPT | Hyp |
|---|---|---|---|
| 24-Hour | | | |
| Baseline Ratio | .04 | -.04 | -.57 |
| Retention Ratio | -.02 | .09 | .25 |
| 2-Week | | | |
| Baseline Ratio | .04 | -.31 | .12 |
| Retention Ratio | -.03 | -.19 | -.02 |

## Appendix M

Littman and Parmalee's (1974) Postnatal and Obstetric Complications Scales

OBSTETRIC COMPLICATION SCALE

(Littman & Parmalee, 1974)

| ITEMS | | |
|---|---|---|
| 1. Gestational age | > 37 weeks | < 37 weeks |
| 2. Birthweight | 2500 gms | < 2500 gms |
| 3. Marital status | Married | Other |
| 4. Maternal age | 18-30 | Other |
| 5. Previous abortions | 2 or less | 3 or more |
| 6. Previous premature births | No | Yes |
| 7. Previous stillbirths | No | Yes |
| 8. Prolonged unwanted sterility | No | Yes |
| 9. Length of time since last pregnancy | >12 months | <12 months |
| 10. Parity | 1 to 6 | 0 or > 7 |
| 11. Pelvis | No Disproportion | Disproportion |
| 12. Rh antagonism or other blood group incompatibility | No | Yes |
| 13. Bleeding during pregnancy | No | Yes |
| 14. Infections or other acute medical problems during pregnancy | No | Yes |
| 15. Drugs given to mother during pregnancy | No | Yes |
| 16. Maternal chronic disease | No | Yes |
| 17. Chronic drug abuse | No | Yes |
| 18. Blood pressure during pregnancy | <140/90 | >140/90 |
| 19. Albuminuria | No | Yes |
| 20. Hyperemesis | No | Yes |

| | | |
|---|---|---|
| 21. Hemoglobin level at end of pregnancy | 10+ | <10 |
| 22. Twins or multiple births | No | Yes |
| 23. Membrane ruptured prior to delivery | 0-12 hours | >12 hours |
| 24. Delivery | Spontaneous | Other |
| 25. Forceps | None or Low | Other |
| 26. Duration, First Stage | 3-20 Hours | <3 or >20 |
| 27. Duration, Second Stage | 10-120mins | <10 or > 120 |
| 28. Drugs during labor and delivery | No | Yes |
| 29. Amniotic fluid | Clear | Other |
| 31. Fetal presentation | Vertex | Other |
| 32. Fetal heart rate during labor | 100-160/Min | <100 or >160 |
| 33. Nuchal or knotted Cord | No | Yes |
| 34. Cord prolapse | No | Yes |
| 35. Placental infarction | No | Yes |
| 36. Placenta previa | No | Yes |
| 37. Onset of stable respiration within 6 minutes | Yes | No |
| 38. Resuscitation required | No | Yes |
| 39. Prenatal care during first half of pregnancy | Yes | No |
| 40. Apgar Score - One Minute | 7 - 10 | 0 - 6 |
| 41. Apgar Score - Five Minute | 7 - 10 | 0 - 6 |

# POSTNATAL FACTORS SCORING SHEET

(Littman & Parmalee, 1974)

ITEMS

1. Respiratory Distress
2. Positive or Suspected Infection
3. Ventilatory Assistance
4. Noninfectious Illness or Anomaly
5. Metabolic Disturbance
6. Convulsion
7. Hyperbilirubinemia or Exchange Transfusion
8. Temperature Disturbance
9. Feeding Within 48 Hours
10. Surgery

# Appendix N

## Summary Tables of Analyses for Experiment 3 Day 1 and 2 Footkick Data Using Combined Fullterm Group

Table N-1

Levene's Test of Homogeneity of Variance on the Day 1 and 2 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 9.9 | 3 | 3.3 | 0.7 |
| Error | 237.9 | 37 | 6.4 | |
| Day | 0.6 | 1 | 0.6 | 0.5 |
| GXD | 5.7 | 3 | 1.9 | 1.5 |
| Error | 45.7 | 37 | 1.2 | |
| Block | 0.1 | 4 | 0.0 | 0.0 |
| GXB | 1.8 | 12 | 0.1 | 0.4 |
| Error | 60.9 | 148 | 0.4 | |
| DXB | 0.0 | 4 | 0.0 | 0.0 |
| GXDXB | 3.2 | 12 | 0.3 | 1.1 |
| Error | 34.9 | 148 | 0.2 | |

Table N-2

Analysis of Variance Source Table for the Mean Number of Kicks in the Initial Three Minutes

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 296.4 | 3 | 98.8 | 0.5 |
| Error | 7856.5 | 37 | 212.3 | |
| Minute | 15.5 | 2 | 7.7 | 0.2 |
| GXM | 184.9 | 6 | 30.8 | 0.8 |
| Error | 2982.1 | 74 | 40.3 | |

Table N-3

Analysis of Variance Source Table for the Groups' Day 1 and 2 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 1139.4 | 3 | 379.8 | 0.5 |
| Error | 25889.7 | 37 | 699.7 | |
| Day | 0.0 | 1 | 0.0 | 0.0 |
| GXD | 561.1 | 3 | 187.0 | 1.4 |
| Error | 4882.7 | 37 | 131.9 | |
| Block | 2219.4 | 4 | 554.9 | 11.5* |
| GXB | 220.2 | 12 | 18.3 | 0.4 |
| Error | 7155.5 | 148 | 48.3 | |
| DXB | 51.4 | 4 | 12.8 | 0.5 |
| GXDXB | 404.9 | 12 | 33.7 | 1.2 |
| Error | 4170.2 | 148 | 28.2 | |

* $p < .001$.

Table N-4

Analysis of Variance Source Tables of the 24-Hour Baseline and Retention Ratios

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| 24-Hour Baseline Ratio | | | | | |
| Groups | 9.3 | 3 | 3.1 | 0.4 | 0.8 |
| Error | 296.4 | 37 | 8.0 | | |
| 24-Hour Retention Ratio | | | | | |
| Groups | 0.4 | 3 | 0.1 | 0.6 | 0.6 |
| Error | 9.1 | 37 | 0.2 | | |
| 24-Hour Savings Ratio | | | | | |
| Groups | 0.7 | 3 | 0.2 | 1.2 | 0.3 |
| Error | 7.3 | 37 | 0.2 | | |

Table N-5

T-Tests Comparing the Groups' 24-Hour Baseline and Retention Ratios to a Theoretical Value of 1.0 and the Savings Ratios to a Theoretical Value of 0

| Group | t-Test Score |
|---|---|
| 24-Hour Baseline Ratio | |
| Fullterm | $t(17) = 1.11$ |
| 24-Hour Retention Ratio | |
| Fullterm | $t(17) = 2.37$ ** |
| 24-Hour Savings Ratio | |
| Fullterm | $t(17) = 2.36$ ** |

** $p < .025$.

# Appendix O

## Summary Tables for Analyses of Experiment 3 Day 16 Footkick Data Using the Combined Fullterm Group

Table O-1

Levene's Test of Homogeneity of Variance on the Day 16 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 8.9 | 3 | 2.9 | 0.8 |
| Error | 127.9 | 36 | 3.6 | |
| Block | 0.1 | 4 | 0.0 | 0.0 |
| GXB | 2.4 | 12 | 0.2 | 0.5 |
| Error | 56.4 | 144 | 0.4 | |

Table O-2

Analysis of Variance Source Table for Day 16 Footkick Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 1054.5 | 3 | 351.5 | 0.8 |
| Error | 15043.1 | 36 | 417.9 | |
| Block | 558.4 | 4 | 139.6 | 3.1* |
| GXB | 281.5 | 12 | 23.5 | 0.5 |
| Error | 6546.9 | 144 | 45.5 | |

* $p < .025$.

Table O-3

Analysis of Variance Source Tables of the 2-Week Baseline and Retention Ratios

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| 2-Week Baseline Ratio | | | | | |
| Groups | 7.0 | 3 | 2.3 | 0.7 | 0.5 |
| Error | 114.8 | 37 | 3.1 | | |
| 2-Week Retention Ratio | | | | | |
| Groups | 0.4 | 3 | 0.1 | 0.3 | 0.8 |
| Error | 15.6 | 37 | 0.4 | | |

Table O-4

T-Tests Comparing the 2-Week Baseline and Retention and Savins Ratios to a Theoretical Value

| Group | t-Test Score |
|---|---|
| 2-Week Baseline Ratio | |
| Fullterm | t(17) = 2.05* |
| 2-Week Retention Ratio | |
| Fullterm | t(17) = 2.46** |
| 2-Week Savings Ratio | |
| Fullterm | t(17) = 0.87 |

* $p < .05$. ** $p < .025$.

## Appendix P

## Summary Tables for Analyses of Experiment 3 Visual Attention Data With the Combined Fullterm Sample

Table P-1

Levene's Test of Homogeneity of Variance for the Day 1 and 2 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 8.7 | 3 | 2.9 | 1.1 |
| Error | 85.0 | 33 | 2.6 | |
| Day | 0.4 | 1 | 0.4 | 0.8 |
| GXD | 3.5 | 3 | 1.2 | 2.4 |
| Error | 16.4 | 33 | 0.5 | |
| Phase | 0.3 | 2 | 0.2 | 0.23 |
| GXP | 4.4 | 6 | 0.7 | 0.97 |
| Error | 49.9 | 66 | 0.8 | |
| DXP | 0.1 | 2 | 0.1 | 0.1 |
| GXDXP | 3.7 | 6 | 0.6 | 1.4 |
| Error | 28.9 | 66 | 0.4 | |

Table P-2

Analysis of Variance Source Table for the Day 1 and 2 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 787.9 | 3 | 262.6 | 0.9 |
| Error | 9497.9 | 33 | 287.8 | |
| Day | 53.6 | 1 | 53.6 | 0.7 |
| GXD | 568.2 | 3 | 189.4 | 2.5 |
| Error | 2467.4 | 33 | 74.7 | |
| Phase | 798.6 | 2 | 399.3 | 3.9* |
| GXP | 351.9 | 6 | 58.6 | 0.6 |
| Error | 6647.6 | 66 | 100.7 | |
| DXP | 57.2 | 2 | 28.6 | 0.5 |
| GXDXP | 558.5 | 6 | 93.1 | 1.7 |
| Error | 3581.9 | 66 | 54.3 | |

* $p < .05$.

Table P-3

Analysis of Variance Source Table for the Groups' Reactivation Treatment Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Groups | 339.3 | 3 | 113.1 | 1.4 |
| Error | 2916.9 | 37 | 78.8 | |

Table P-4

Levene's Test of Homogeneity of Variance for the Day 16 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 15.1 | 3 | 5.0 | 3.6* |
| Error | 47.6 | 34 | 1.4 | |
| Phase | 0.2 | 2 | 0.1 | 0.2 |
| GXP | 4.8 | 6 | 0.8 | 1.6 |
| Error | 32.4 | 68 | 0.5 | |

* $p < .05$.

Table P-5

Analysis of Variance Source Table of Day 16 Visual Attention Data

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Group | 1136.9 | 3 | 378.9 | 2.6 |
| Error | 5034.8 | 34 | 148.1 | |
| Phase | 1199.4 | 2 | 599.7 | 8.3* |
| Phase X Group | 430.5 | 6 | 71.7 | 0.9 |
| Error | 4909.2 | 68 | 72.2 | |

* $p < .001$.