FINAL PROGRESS REPORT

To: Bial Foundation

From: Jerome Kagan, Research Professor of Psychology, Harvard University

Title of Project: Newborn Predictors of Reactivity at Four Months

Period Covered by This Report: January 1, 2001 to December 31, 2001

Purpose

The purpose of the research is to determine the relation between the temperamentally based characteristics of the newborn and the temperamental category to which the four-month old infant is assigned. The four-month old temperamental categories of high and low reactivity have been shown to be predictive of both behavior and physiology through ten years of age. Thus, it is of great theoretical interest to determine if aspects of the newborn behavior contain signs of the four-month temperamental category.

Method

Subjects. The subjects in this research were 72, healthy newborn infants born at term in a Boston hospital. A total of 58 of these infants (80 percent of the newborn sample) were able to return for an evaluation of temperament at four months of age.

Newborn Assessment. Each newborn infant was administered a modified version of the Brazelton Newborn Examination (see Appendix). The episodes included:

1) Reaction to light and sound while the infant slept. Most of the infants were sleeping when the examination began. The examiner presented repeated flashes of light followed by repetition of sounds until there was habituation of any motor reaction to the stimuli.
2) Reflexes. The infant was then uncovered and later undressed and administered an examination for basic reflexes. Almost all the infants were aroused by being unswaddled and undressed. If the infant cried, the examiner followed a fixed regimen of behavior to calm the infant. If the infant was still crying after 15 seconds following the initial distress, the examiner tried to quiet the infant, first by talking,

and then by placing her hand on the chest of the infant. If these procedures did not work, she then swaddled the infant, and if that procedure did not quiet the infant, then she picked the infant up. This continued until the infant was quiet.

3) Reaction to voice and sound. The examiner then held the infant in front of her and first spoke to the infant, changing her orientation from left to right. This was followed by sounding a rattle to the left and right of the infant's head.

The major variables coded from the newborn examination were the duration of crying, and the time to console the infant once it began to cry.

Four-month evaluation. The infants came to the laboratory at William James Hall at Harvard University to be tested at four months of age. (For details see Appendix) The episodes were:

1) The mother looked down at the infant for one minute.
2) The infant heard a series of sentences coming from a speaker with no human in sight.
3) A set of mobiles were presented to the infant.
4) A cotton swab dipped in butyl alcohol was presented to the infant for a series of trials.
5) A second set of mobiles was presented.
6) The mother looked down at her infant for the final minute.

The filmed records of the child's behavior were coded for motor activity and crying, and each four-month old infant was assigned to one of three categories: high reactive, based on high levels of motor activity and crying, low reactive, based on minimal motor activity and minimal crying, and other.

Physiology. Following the behavioral assessment of reactivity, several physiological variables were measured. These included heart rate and EEG. It was not possible to gather the biological data on all of the infants, either because the infant fell asleep, or was too irritable.

Results

Relation between newborn and four-month behavior. Table 1 contains the evidence summarizing the relation between irritability and ease of being consoled during the newborn period and each of the three categories of reactivity at four months of age.

Two-thirds of the infants who were classified as high reactive were extremely irritable and hard to console during the newborn period, compared with 20 percent of those who were categorized as low reactive and 24 percent of the four-month olds who were classified as neither high nor low reactive. A comparison of those who were high reactive versus others yielded a chi-square of 7.3, $p<.01$.

Thus, the evidence indicates that the newborns who were extremely irritable and hard to console – about one-third of all the newborns – were significantly more likely to be classified as high reactive at four months.

Physiology

Cardiac Activity. We gathered data on mean heart rate and mean heart rate variability. Research by many investigators has shown that high sympathetic reactivity is associated with a lower heart rate variability, and we have found in previous research that high reactive infants tend to show sympathetic reactivity in the cardiovascular system.

Figure 1 shows that the newborns who cried frequently and were hard to soothe had lower heart rates and less heart rate variability than the complementary group of infants who cried infrequently and were easy to soothe. Although the heart rate measures were not related to the four-month temperamental categories, the fact that the newborns who were hardest to console had less variable heart rates is in theoretical accord with our hypothesis that infants with a lower threshold for distress and a compromised regulatory system have a more reactive sympathetic nervous system. Because the amygdala is an important origin of sympathetic reactivity, these data can be interpreted as providing support for the hypothesis that variation in amygdalar excitability is associated with temperamental types.

EEG. We were able to obtain resting EEG on a part of the sample. The major variable of interest was the amount of power in the 6-9 Hz frequency band period. This frequency band in infants is regarded as similar in meaning to the alpha band (8-13 Hz) obtained in adults. High power in the alpha band usually accompanies a relaxed state and low arousal, while low power accompanies a more aroused state.

We did not find a relation between the infants' behavior and power in the 6-9 Hz band. However, the four-month olds with higher heart rates had less power in the 6-9 Hz band, implying greater cortical arousal (see Figure 2).

Maternal Diary. Each mother of the four-month sample kept a diary for one day prior to the four-month visit to the laboratory (see Appendix). The diary contained the mother's observations of her infant for that day. Examination of the diaries revealed that infants classified as high reactive at four months were described by their mother as more irritable and fussier than other infants ($t = 2.79$, $p<.01$). This result could not have been influenced by the mother's observation of her four-month old in the laboratory because the infant had not yet been tested when the diary was completed. Thus, these data indicate that high reactive infants are more irritable in the home setting.

Summary

The results of this work add a very important fact that aids our understanding of the high reactive infant. Prior research, supported in part by the Bial Foundation, established that high reactive infants are biased to develop shy, timid personalities as well as a physiology suggesting high cortical and autonomic arousal at age 11 years. These facts, together with the research of others, argue for a heritable component to high reactivity. This premise implies that newborns who have become high reactive at four months should be different from other newborns in ways that imply ease of arousal and a compromised ability to regulate that arousal. The evidence from this research affirms that expectation, for the newborns that cried a great deal and were difficult to console were most likely to become high reactive at four months of age. These infants were fussier and more irritable in the home setting and had less variable heart rates. The latter measure implies higher sympathetic tone in the sympathetic nervous system. Thus, the results of this project suggest that further study of the period between birth and four months will be illuminating.

Table 1. Relation Between Newborn Behavior and 4 Month Temperament

Newborn	High Reactive	Low Reactive	Other	Total
Low Cry Easy to Soothe	2	19	11	16
High Cry Hard to Soothe	6	5	5	32
Other	1	3	5	9
Total (N=57)	9	27	21	57*

*N=57 because 1 four month old was extremely deviant and not classifiable.

Figure 1. Newborn Behavior by 4 Month Heart Rate Variability Stand

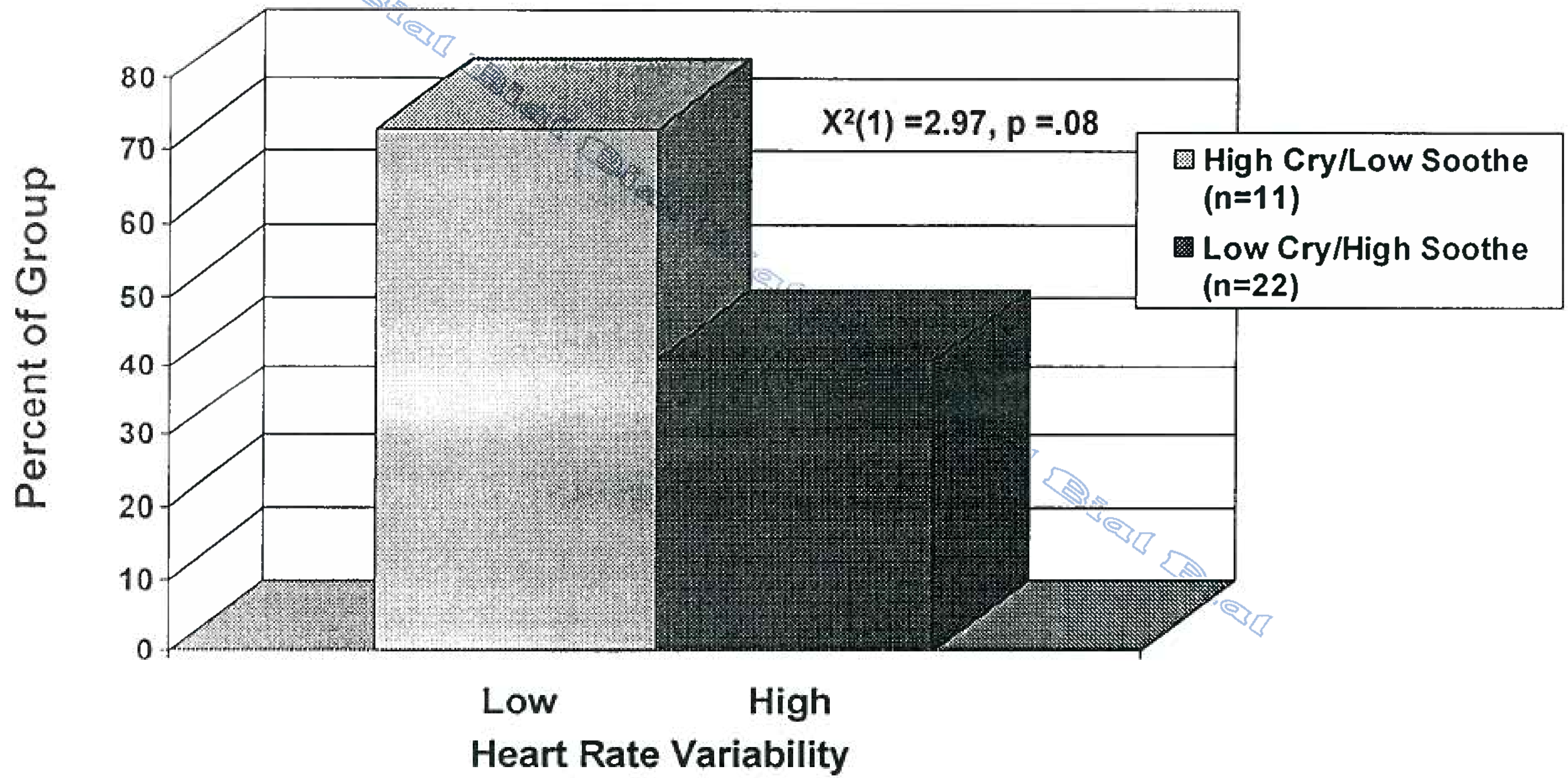
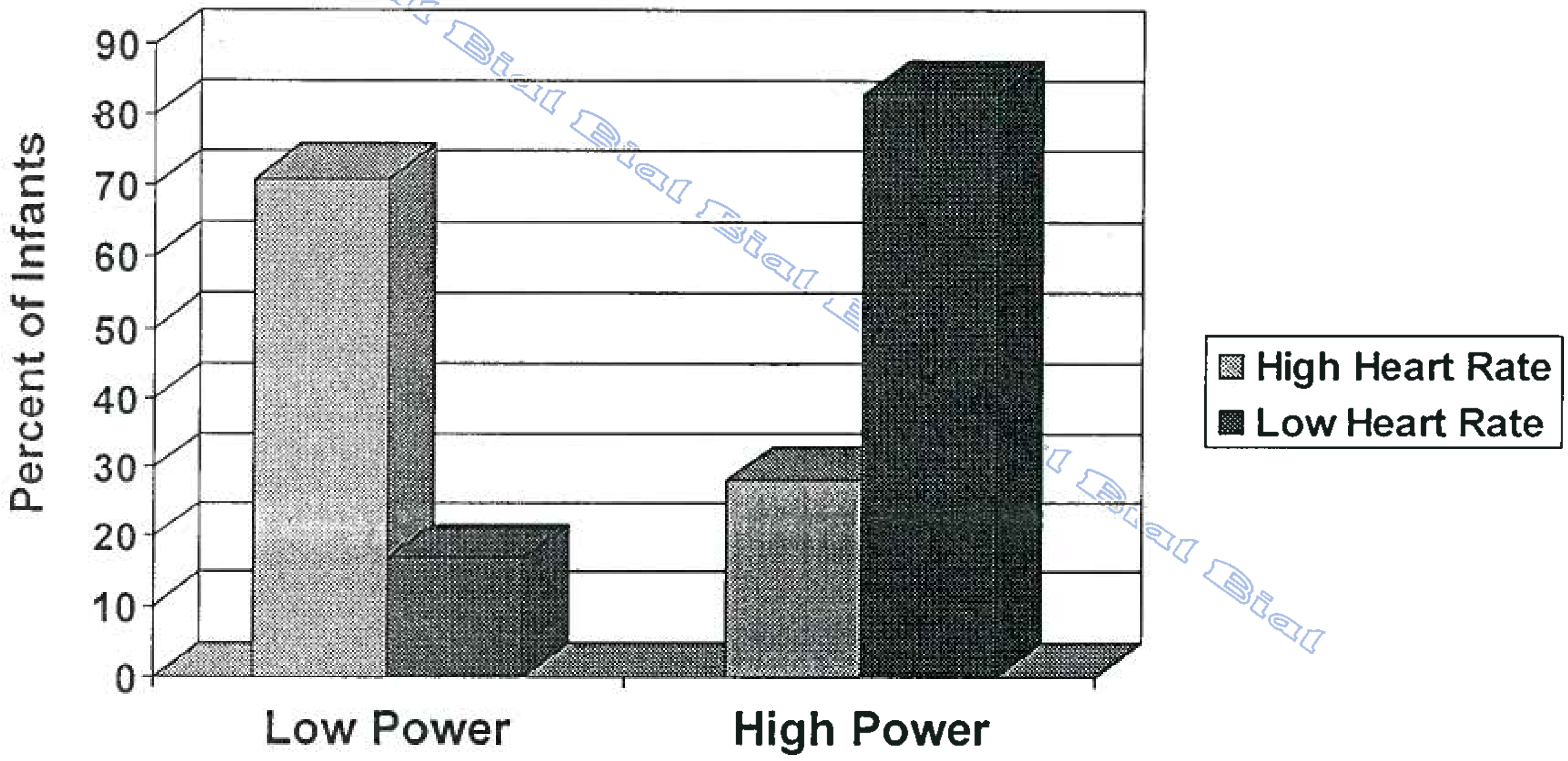


Figure 2. 4 Month Supine Heart Rate and EEG Power: 6-9 Hz Band



Appendices

code nr.

NBAS-R SCORING FORM

room:

Name | Sex | Date of Birth
Gestational Age | Weight | Height
Head Circumference | Length of Labour | Apgar Scores
Delivery | Type of feeding | Examiner | Date of Exam

Habituation	9	8	7	6	5	4	3	2	1	Comments
Resp. dec. to light										
Resp. dec. to rattle										
Resp. dec. to bell										

Orientation	9	8	7	6	5	4	3	2	1	Comments
Anim. visual & auditory										
Animate visual										
Animate auditory										
Inanim. visual & auditory										
Inanimate visual										
Inanimate auditory										
Alertness										

Motor System	9	8	7	6	5	4	3	2	1	Comments
General tone										
Motor maturity										
Pull to sit										
Defensive										
Activity level										

State Organization	9	8	7	6	5	4	3	2	1	Comments
Peak of Excitement										
Rapidity of Buildup										
Irritablity										
Lability of States										

State Regulation	9	8	7	6	5	4	3	2	1	Comments
Consolability										
Self-quieting										
Hand-to mouth										

Autonomic System	9	8	7	6	5	4	3	2	1	Comments
Tremulousness										
Startles										
Lability skin color										

Order of Presentation:

1. Habituation to Light
2. Habituation to Raffle
3. Habituation to Bell

Uncover

4. Plantar
5. Babinski
6. Ankle clonus
7. Passive tone in legs
8. Passive tone in arms
9. Rooting
10. Sucking
11. Glabella

Undress

12. Palmar
13. Pull-to-sit
14. Standing
15. Walking
16. Crawling
17. Incurvation
18. 30-second observation of spontaneous motor activity
19. Defensive
20. Moro
21. Animate visual and auditory
22. Animate visual
23. Animate auditory
24. Inanimate visual and auditory
25. Inanimate visual
26. Inanimate auditory

Administration of Items:

Habituation

Present stimulus 10"-12" from infant every 5 seconds (equidistant intervals) up to ten times or until there are two presentations without a response from the infant.

<u>Light</u>: Shine the light directly on the infant's eyes. Let the light linger for 1 second.

<u>Rattle</u>: An audiotape will be played through a speaker placed at the edge of the bassinet near the infant's head. The tape will contain a sequence of sounds made by a rattle, for the duration of 1-second each, at an intensity of 70 decibels.

<u>Bell</u>: An audiotape will be played through a speaker placed at the edge of the bassinet near the infant's head. The tape will contain a sequence of sounds, made by a bell, for the duration of 1-second each, at an intensity of 70 decibels.

Motor

Administer all the motor/reflex items from Plantar reflex to the Moro reflex in order, unless infant moves into state 6 for 15 seconds. If the infant has been in state 6 for 15 seconds, the examiner should stop and administer the consolability maneuvers. If infant consoles him/herself before 15 seconds pass, continue with the administration of the reflexes in the established order. The Consolability item should be administered in its entirety only once during an exam. If the infant reaches state 6 again for 15 seconds, use whatever strategy worked in the first administration of the Consolability item.

Continue with the administration of the motor items when the infant reaches a lower state. If infant never reaches a state 6 and only reaches a state 5, continue with the administration of the motor items. If the infant becomes alert and reaches a state 4 during this time, do not break for the Orientation items, but wait until after the Moro response.

After the Incurvation item, place the infant in supine and observe his/her spontaneous motor activity for 30 seconds. For the administration of this item the infant should be placed in the bassinet in supine. The examiner should observe spontaneous motor activity for 30 seconds. If the infant reaches state 6 for 15 seconds, discontinue the administration of the 30-second observation. Once the infant has been consoled, proceed to administer the Defensive and the Moro items.

Order of presentation of the motor/reflex items:

Plantar grasp
Babinski
Ankle clonus
Passive Tone - legs
Passive Tone - arms
Rooting (use latex-free glove)
Sucking (use latex-free glove)
Glabella
Undress
Palmar grasp
Pull-to-sit
Standing
Walking
Crawling
Incurvation
Observation of Spontaneous Motor Activity
Defensive movement
Moro

Consolability:

The full Consolability item is administered only once during the evaluation. It should be administered when the infant has been in state 6 for at least 15 seconds (during these 15 seconds continue administering the scale items). The first maneuver of consolability is to stop administering the scale items and give the infant 10 seconds to see if she can self-quiet. If she continues to cry, begin with the presentation of the face alone for 10 seconds. If this fails to bring the infant to a lower state, present face and voice for another 10 seconds. If she still cannot be consoled, move on to placing your hand on her belly for another 10 seconds. This is followed by restraining both arms, then picking up and holding, holding a rocking, swaddling the infant, and finally, if she still cannot be consoled, use a pacifier or a gloved finger, in addition to holding and rocking her. You should allow 10 seconds for each one of these steps. When talking to the infant, use a calming voice and use consoling words, such as "Don't cry baby", "It's OK", "You'll be OK".

Orientation

Order of social interactive items:

1. Animate visual and auditory
2. Animate visual
3. Animate auditory
4. Inanimate visual and auditory
5. Inanimate visual
6. Inanimate auditory

Administration of Orientation items:

Preparation for the administration of Orientation Items:

- First, swaddle the infant
- Do not provide the infant with a pacifier.
- Remain standing for the administration of the animate items. Take time (up to two minutes maximum) to ensure the infant is in a testable alert state (state 4) before administering the first item. If the infant is drowsy, for example, use vestibular stimulation to arouse her. If the infant is upset, use consoling maneuvers to help her settle so that she can come into an alert state 4. After the administration of each item in the Orientation package, take up to one minute (if necessary) before you proceed to the next item, to ensure the infant is still in a testable state 4.

Begin with the **animate visual and auditory** item, keeping the infant's head in midline.

- Hold the infant at an angle of 45 degrees (in a semi-upright position), using both hands to support the infant, with one hand supporting the infant's head. Place the infant in midline before you begin to move to the side.
- Engage the infant in a face-to-face position about 10"-12" from her eyes, for 5 seconds, before you begin to move to the side, using your face and voice to engage her attention. Do not go beyond infant's range of vision.
- Move your face slowly and smoothly to the infant's left (your right), while saying "hello baby" (with medium intensity tone of voice) at a pace that takes 5 seconds to move from 0 to 60 degrees.
- Move the infant's head back to midline (if necessary) and repeat on the infant's right (your left).
- Finally, gently move the infant's head back to midline (if necessary) once more and move your head vertically at a pace that takes 5 seconds to go from midline to a vertical angle of 30 degrees. Observe the range of movement of the infant's eyes and head.

Next, proceed to administer the **animate visual** item by following the same procedure described above. Again, engage the infant with your face at about 10"-12" from her eyes, for up to 5 seconds. Begin at midline and move slowly at a pace that takes 5 seconds to move from 0 to 60 degrees to the infant's right, etc.

Finally, proceed to the **animate auditory** only item. Begin on the infant's right, with your face out of the infant's range of vision at an angle of 60 degrees. Repeat "hello baby" (soft/medium intensity tone of voice) for 10 seconds. Bring the infant's head back to midline (if necessary) and repeat this procedure on the other side.

Preparation for the administration of the inanimate items:

- Keep the infant swaddled.
- Do not provide the infant a pacifier.
- Sit for the administration of the inanimate items. Take time (up to two minutes maximum) to ensure the infant is in a testable alert state, (state 4), before administering the first item. If the infant has become drowsy, again use gentle vestibular stimulation to arouse her. If the infant is upset, use consoling maneuvers to help her settle so that she can come into an alert state 4. After the administration of each item, take up to one minute (if necessary) before you administer the next item, to ensure the infant is still in a testable state 4.
- Place the infant on your lap at an angle of 45 degrees (in a semi-upright position). Use a footstool if possible. You need to have one hand free to hold the rattle and ball.

Begin with the **inanimate visual and auditory item.**

- Place the infant on your lap. Hold the infant at an angle of 45 degrees (in a semi-upright position), using one hand and your lap to support the infant, with your hand supporting the infant's head. Place the infant in midline before you begin to move to the side.
- Engage the infant with the rattle at about 10"-12" from her eyes for up to 5 seconds. Shake the rattle continuously at a medium intensity at midline.
- Move the rattle slowly to the infant's left (your right), at a pace that takes 5 seconds to move from 0 to 60 degrees. Do not go beyond infant's range of vision.
- Move the infant's head back to midline (if necessary) and repeat on the infant's right (your left). The presentation is done once on each side.
- Finally, gently move the infant's head back to midline (if necessary) once more and, shaking the rattle, move it slowly vertically at a pace that takes 5 seconds to go from midline to a vertical angle of 30 degrees. Observe the range of movement of the infant's eyes and head.

Next proceed to administer the **inanimate visual** (red ball) item by following the same procedure as above for the inanimate visual and auditory. Again, engage the infant with the ball at about 10"-12" from her eyes, for up to 5 seconds. Begin by holding the red ball at midline and move slowly at a pace that takes 5 seconds from 0 to 60 degrees to the infant's right, etc.
Finally, administer the **inanimate auditory** (rattle) item. Shake the rattle at a 60-degree angle on the infant's right side first. Shake the rattle continuously in a back and forth movement, at a moderate level of intensity for 10 seconds. Bring the infant's head back to midline (if necessary) and repeat on the other side. This will be done once on each side.

The 4-Month Temperament Assessment

All the infants are observed in a laboratory setting. The four-month temperament battery evaluates infant reactivity to unfamiliar stimuli in varied modalities. Each episode is designed to increase in stimuli intensity and complexity over a series of trials. The examiner hasno knowledge of the infant's behavior on the newbornassessment. The assessment protocol lasts approximately one hour, depending on the number of breaks needed for feeding, comforting, or sleeping.

- Baseline 1. The mother stands at the foot of the infant seat looking at, but not touching or speaking to, the seated infant for one minute.

- Auditory. An audiotape is played through a speaker placed at the foot of the infant seat and covered with a schematic face to attract the infant's attention to the speaker. The tape contains pairs of sentences read by one, two, three, or four people in sequence for a total of 8 trials, each pair increasing in intensity by 5 decibels starting at 60 dB(A) which is the level of a quiet speaking voice.

- Mobiles 1. The infant is shown 3 different mobiles. The first mobile contains 1 object; the second mobile contains 3 objects, and the third contains 7 objects. The mobile is moved back and forth slowly in front of the infant's face, at an approximate rate of one swing per second, for trials 20 seconds in duration. This series is repeated 3 times for a total of 9 trials.

- Olfactory. The infant is presented with a series of cotton swabs approximately one centimeter in front of the nostrils for five seconds with five seconds between each trial. The swab is soaked in one of the following: one trial distilled water, three trials .0008% butyl alcohol, three trials .0016% butyl alcohol, and one final water trial, for a total of eight trials.

- Mobiles 2. A second series of mobiles is presented to the infant. The procedure is identical to the first series, but the elements of each mobile has different shapes and colors.

- Baseline 2. The mother stands at the foot of the infant seat looking at, but not touching or speaking to, the seated infant for one minute.

Using the "Baby's Day Diary"

Thank you for agreeing to participate in this study by completing the "baby's day diary!"These simple instructions are to **introduce** you to the diary, and to show you **how simple it is to complete.** Here they are:

1. First, don't panic. Probably when you first look at the diary, it will appear very complex and very complicated. **It is not!**

2. Second, you are **not expected to fill it out minute by minute!** The purpose of the diary is not to get extremely fine-grained accuracy, but rather a generally accurate recording of your infant's behaviors (and some of your care-giving routines) over a day. Most mothers find it easiest to fill out the diary **every 1 to 3 hours** or so, usually in association with a recurrent activity, like feeding or changing the baby.

3. The only thing you are asked to do is fill in the blocks of time (in the "time rulers") with the available symbols. Your **baby's behaviors** go in the **top half** of the time ruler, and **your own care-giving behaviors** go in the **bottom half** of the time ruler.

4. To make it easy, the whole day is represented as 4 "time rulers", each representing six hours for the nighttime (MIDNIGHT to 6:00 AM), morning (6:00 PM to MIDNIGHT). **We don't expect you to describe anything that lasts less than 5 minutes.** Most of these behaviors last at least 5 minutes (like fussing and crying), and often for hours (like sleep).

5. The possible **baby behavior codes** are represented on the **left side** of the page. They are all behaviors your infant does over and over throughout the day and night. When you use the symbols in the time rulers, it lets us know when, and for how long, these behaviors occur.

*Note that at the end of the day, the upper ruler should be completely filled from MIDNIGHT to MIDNIGHT with baby behavior codes

6. The possible **care-giving codes** (what you do with your baby) are represented on the **right side** of the page. The symbols let us know when, and for how long, these care-giving activities occur.

* Note that since you are not doing these things with the baby all day and all night long, there will be some blank spaces in the lower ruler.

7. We understand that there may be times when you are not with your infant or can't remember. That's OK! If so, use the "out of the house or can't remember" code in the baby's part (upper section) of the time ruler.

8. A frequently asked question: "**Can anyone complete the diary, or must I do it all?" ANSWER: YES, anyone** can complete the diary. For example, if you go to the store and someone else is with your baby, just ask them to complete it while you are gone.

9. The **two-page description of the codes** is simply to illustrate how the codes are used. You will probably find that once you start, you won't have to look at these sheets ever again.

10. THAT'S IT! Try it. **Have fun** with the diary, but **especially with your baby**. It will be interesting for you and us to see how your baby changes, and stays the same, from day to day.

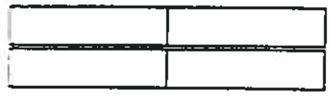
If you have any **questions**, please don't hesitate to call 617/495-3885 ....Leave a message if we are not there. We will call you back as soon as we can.

THANKS!

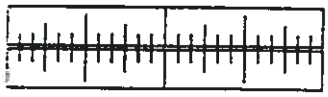
Instructions for completing the "Baby's Day" Record

This record of the baby's day is designed to permit you to record the baby's behavior and your own activities with the baby over a continuous 24 hour period. As you can see, one whole day is represented by four bars consisting of **two** "ruler"-like parts.

These have marked subdivisions representing 1-hour intervals



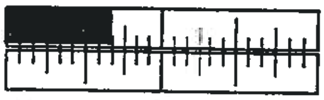
and further marked subdivisions representing 5-minute intervals.



The top "ruler"-like part is designed for recording the baby's behavior.

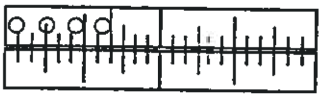
The behaviours are each represented by a different type of shading or symbol. Only one type of shading is represented at a time, and can be filled in as follows:

(1) When your baby is **sleeping**, fill in the space with solid shading like this:



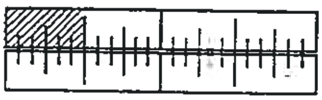
= 40 minutes sleeping.

(2) When your baby is **awake and content**, draw circles in the space, ending at the last time bar:



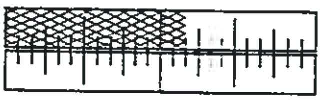
= 40 minutes awake and happy.

(3) When your baby is **awake and fussy**, - making unhappy sounds but not actually crying - fill in the space with diagonal lines:



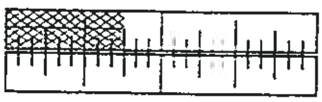
= 30 minutes of fussing.

4) When your baby is **awake and crying**, cross-bar the space:



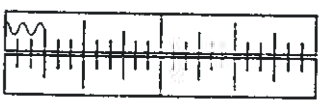
= 70 minutes of crying.

5) When your baby is **crying and cannot be soothed**, cross-bar the space and put a line through it:



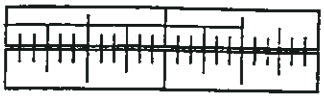
= 45 minutes of unsoothable crying.

6) When your baby is **feeding**, show a squiggled line through the space:



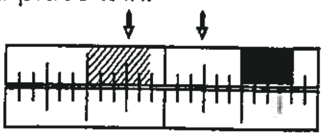
= 15 minutes of feeding.

(7) When you **go out or don't remember** your baby's behaviour, draw a straight line through the space:



= 1 hour & 30 minutes of absence.

(8) Finally, when you **place a pacifier** in your baby's mouth, put an arrow above the baby's ruler at the time you place it in:

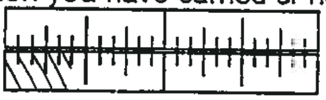


= Pacifier inserted at 45 minutes and 1 hour & 15 minutes.

<u>The bottom "ruler"-like part</u> is designed for recording your caregiving activities with the baby.

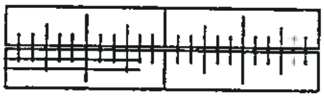
The parental activities, too, are each represented by a different type of shading or symbol.
Only **one type** of shading is represented at a time, and can be filled in as follows:

(1) <u>Body Contact:</u>
When you have carried or held or rocked the baby **on your body,** fill in the space with diagonal lines:



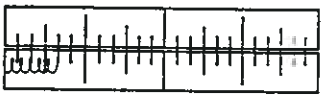
= 25 minutes of moving the baby with body contact.

(2) <u>Moving:</u>
When the baby is **moved without body contact,** (e.g. in the baby carriage, pram, in a "baby cot", or during car driving), fill in 2 straight lines:



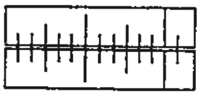
= 50 minutes of moving the baby without body contact.

(3) <u>Care</u>: changing, dressing, bathing
When you change the diapers, dress or bathe your baby, draw a squiggled line:



= 20 minutes of care activities.

(4) When you don't direct any of the indicated activities to the baby, just leave the space blank:



= 70 minutes without parental activities
other than those mentioned above
(e.g. talking alone, visual contact alone, etc.)

EXAMPLE

DATE :

NAME :

SLEEPING

AWAKE & CONTENT

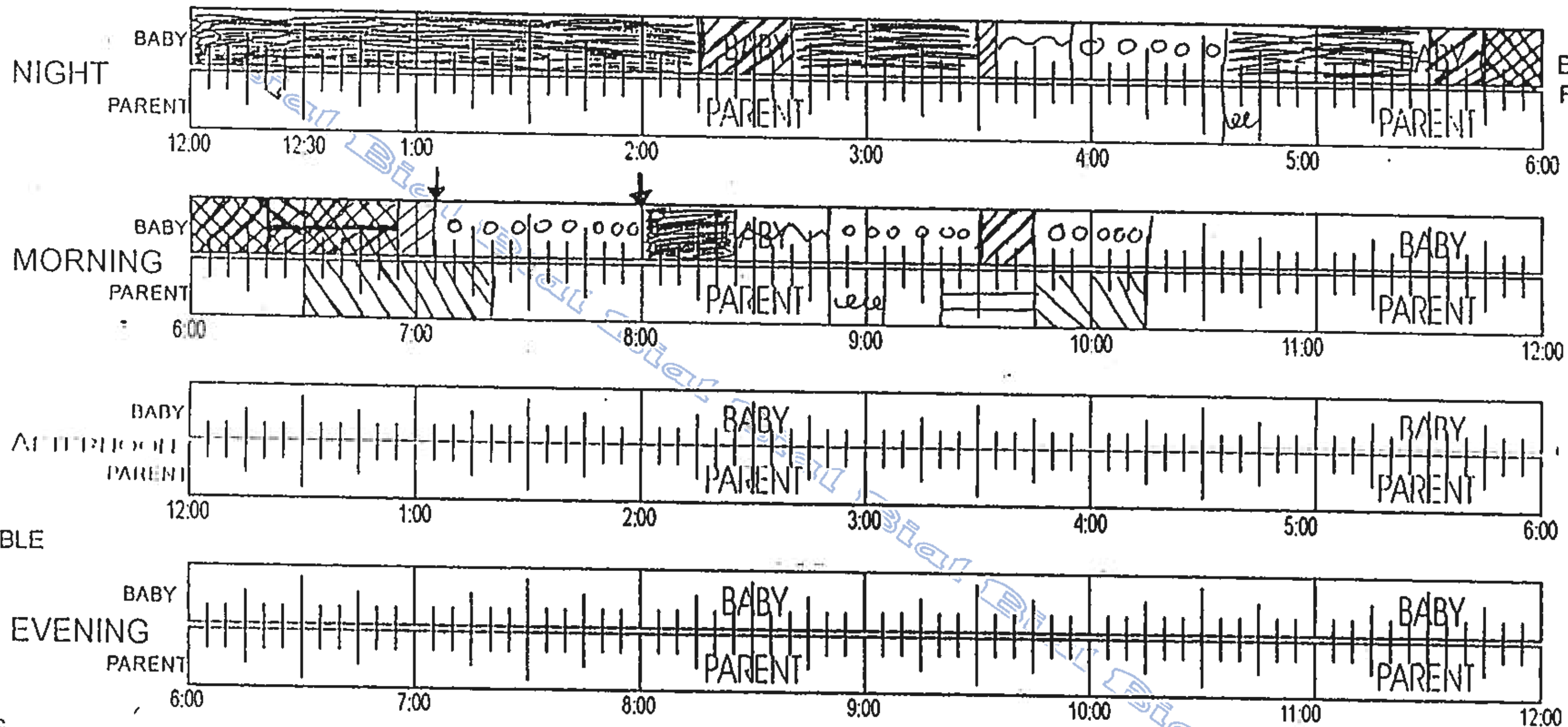
AWAKE & FUSSY

AWAKE & CRYING

UNSOOTHABLE CRYING

FEEDING Breast/Formula

CANNOT REMEMBER



Parent Codes

BODY CONTACT Rocking/Carrying

MOVING by baby carriage/ car driving

CARE changing, bathing, dressing

Thank you for completing the diary! Please check that the baby "ruler" is completed with baby codes throughout the day.

Was this a "typical" day ? ☐ YES

☐ NO

→ Please explain : ____________________

★ Please indicate (with an arrow ↓) each time you give the baby a pacifier.

For example:

DATE :

NAME :

DAY __

SLEEPING

AWAKE & CONTENT

AWAKE & FUSSY

AWAKE & CRYING

UNSOOTHABLE CRYING

FEEDING Breast/Formula

CANNOT REMEMBER

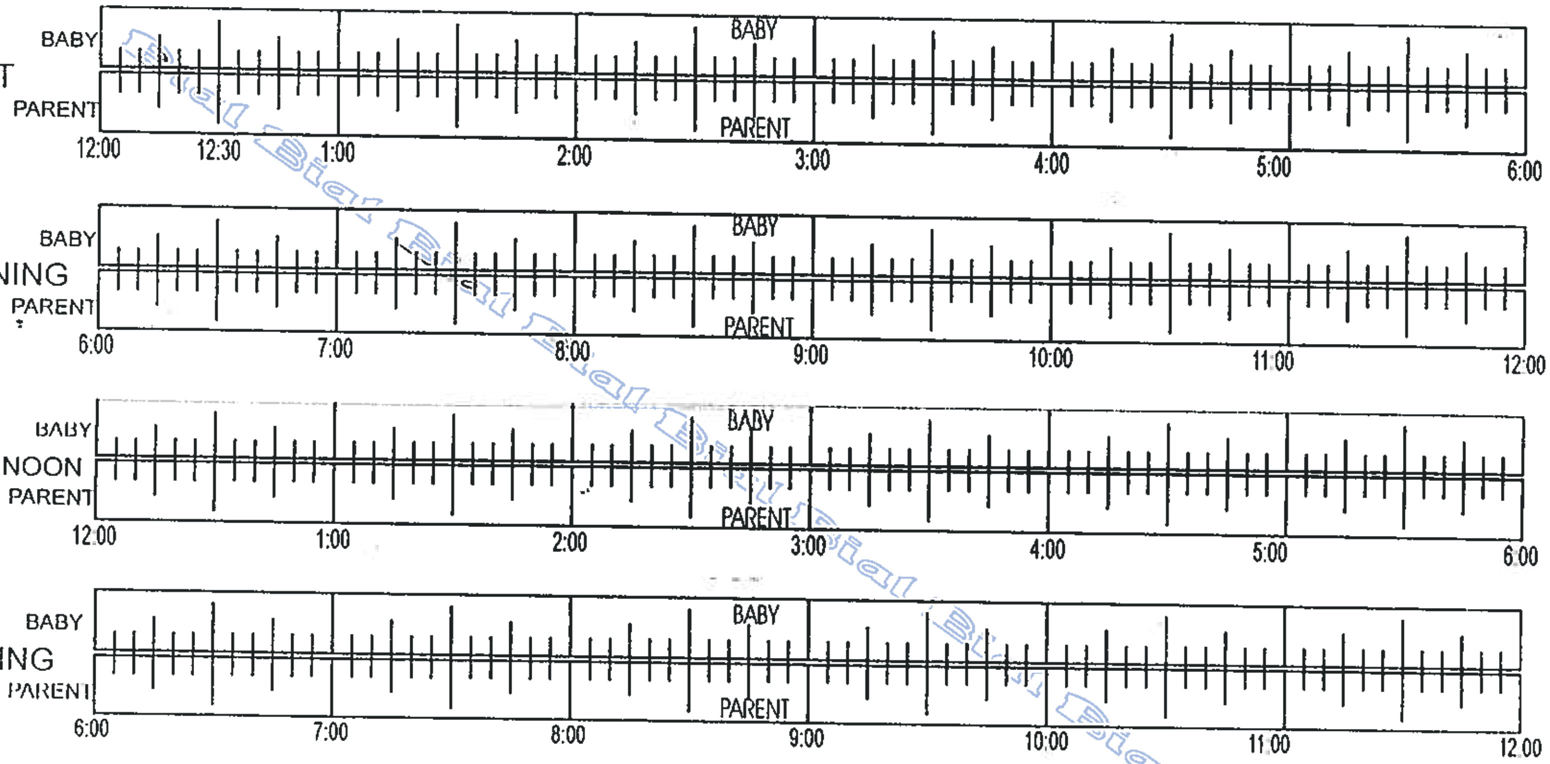
Thank you for completing the diary! Please check that the baby "ruler" is completed with baby codes throughout the day.

NIGHT

MORNING

AFTERNOON

EVENING



Parent Codes

BODY CONTACT Rocking/Carrying

MOVING by baby carriage/ car driving

CARE changing, bathing, dressing

Was this a "typical" day ?

☐ YES

☐ NO

Please explain : ____________________

★ Please indicate (with an arrow ↓) each time you give the baby a pacifier.

For example: