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ABSTRACT

The role of genetic factors in infant response to redundancy was evaluated through observation of the behavior of three sets of same-sex fraternal twins and six sets of same-sex identical twins to combinations of redundant proprioceptive and auditory stimulation. The twins ranged in age from 6 weeks to 24 weeks. One member of each twin set was placed on each side of a partition in a motor-driven rockerbox, and four 1-minute treatments were administered in mixed order, with 1-minute pre-treatment and post-treatment periods. The treatments consisted of combinations of fast and slow rocking under conditions of sound and no sound. An observer rated the activity level of each twin on a 5-point scale at 30-second intervals. Treatment was associated with a significant decline of infant activity independent of zygosity. Identical twins exhibited marked behavioral consistency compared to fraternal twins during and after treatment. The results appear to provide positive evidence for the role of endogenous, genetically linked regulation of infant response to redundant stimulation. (Author/NH)

RB-71-9

# INFANT REACTIVITY TO REDUNDANT PROPRIOCEPTIVE AND AUDITORY STIMULATION: A TWIN STUDY

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Infant Reactivity to Redundant Proprioceptive and Auditory Stimulation: A Twin Study[1]

Leland D. Van den Daele[2]

Educational Testing Service

## A. Introduction

When an infant is rocked his state changes from greater to lesser activity and his mood from distress to relative quiescence. This effect, designated the rockerbox effect, appears largely independent of sex, age, maternal presence or absence, or parental practices related to previous rocking experience (15). Decrement of pre-treatment activity, however, varies with rocker rate (7, 15) as well as initial state (15).

Redundant sound is another class of stimulation with similar consequences for infant behavior. Exposure to continuous or intermittent sound reduces infant activity more than no sound at all (1, 13, 16). This effect, like the rockerbox effect, appears independent of reinforcement history or pre-treatment experience associated with sound (2, 12). Both effects implicate an unlearned response or at least a dispositional tendency to respond in a characteristic way to redundant stimulation.[3]

One test of this implication is a behavior genetic analysis (8). Twin designs, which compare the relative differences between monozygotic and dyzygotic pairs, provide a simultaneous control for age and generational factors which often confound developmental evaluation (10). When twins are selected from intact families, a rigorous match is obtained for the general factors which relate to health care and nutrition, availability of stimulation, and maternal care and social interaction. Differences in behavioral variability between fraternal and identical twins may be imputed to dispositional differences, or, at least, dispositional differences which interact with antecedent experience. The method provides positive presumptive evidence for the role of endogenous factors in behavioral regulation.

## B. Method

### 1. Subjects

Ss were six same-sex identical and three same-sex fraternal twin sets. The twins ranged in age from 6 weeks to 24 weeks with a median age of 18 weeks for identical twins and 20 weeks for fraternal twins. Although two identical and two fraternal twin pairs were premature, all Ss were free from overt morphological or anatomical anomalies. Diagnosis of zygosity was obtained through chorional and seriological examination, and, when these data were unavailable, dermatoglyphic and physical concordance (9).

### 2. Apparatus

A 32-inch square, motor-driven rockerbox was divided into two equal compartments by a 14-inch-high partition. The rockerbox was adjusted to oscillate in a head-to-foot direction with a displacement of three inches at either 30 or 60 cycles per minute. An 80 db. white noise source was placed 30 inches horizontally to the longitudinal axis of the rockerbox.

### 3. Procedure

In a previous study, the rockerbox effect was exaggerated with irritable infants (15). Since irritability is more pronounced when infants are hungry (17), mothers were instructed not to feed their twins for at least two hours prior to treatment. Two mothers, one of an identical pair and one of a fraternal pair, did not comply, but the infants were in a wakeful state.

One member of each twin set was placed on each side of the partition. Four treatments were administered in a mixed order. The treatments were combinations of slow and fast rocking under no sound and sound conditions. Each treatment was one minute in duration preceded and followed by one minute pre- and post-treatment periods. The activity level of each twin was rated on a 5-point scale at 30-second intervals by an observer out of the infants' visual field from the onset of the pre-treatment to the conclusion of the post-treatment period. A rated response of one corresponded to inactive, sleeping; two, slightly active, drowsy; three, moderately active, alert, seeking; four, very active, grasping, restless; five, highly active, gross body movement, thrashing (14). Interrater reliability for a similar task with the same scale was .86 between two independent observers for 768 paired observations (15) and, in the present study, .90 for 52 paired observations.

## C. Analysis 1: Group Treatment Effects

### 1. Results

A four factor ANOVA was calculated to evaluate the main effects and interactions of treatment combinations. Factor A, auditory stimulation, included two levels, no sound and sound, and Factor B, proprioceptive stimulation, two levels, slow and fast rocking. Factor C, periods, was comprised of three intervals, the pre-treatment, treatment, and post-treatment periods, and Factor D, trials within intervals, six consecutive ratings of activity level. Trials were nested within periods. Data for two Ss for two and three treatments respectively were estimated. The former S was a member of a fraternal set, the latter a member of an identical set. After treatment these Ss fell asleep and were not roused by a bell or manual manipulation. The degrees of freedom for significance tests were correspondingly reduced. Significance for treatment effects was set at or beyond the .01 level of confidence.

Two main effects and one interaction obtained significance for group data (Table 1). The proprioceptive treatment for all conditions had a marked

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Insert Table 1 about here

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effect on infant state (C effect), with infants less active when rocked. The group means for pre-treatment, treatment, and post-treatment periods were 3.33, 2.02, and 2.85 respectively. After treatment, recovery in the direction of previous state was gradual with the group means for the fifth trial 2.66 and for the sixth trial 3.03 (D effect). Finally, treatments accompanied by sound were more quieting than treatments not accompanied by sound (AC interaction, Figure 1).

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Insert Figure 1 about here

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## 2. Discussion

The general effectiveness of the rockerbox treatment found in an earlier study (15) was replicated. Irritable infants became less active and more quiescent when rocked. The effect persisted into the post-treatment period with gradual recovery toward pre-treatment levels. When pre-treatment ratings were divided at the scale median into high and low groups and difference scores between pre- and post-treatment state computed, infants initially above the scale median were significantly less active after treatment than infants below the scale median ($t = 2.98$, 51 df, $p < .01$). The post-treatment payoff was larger with active infants.

White noise concomitant with rockerbox treatment depressed activity more than rockerbox treatment alone. This result is reminiscent of the additive effect of light and sound demonstrated by Irwin and his co-workers summarized by Spears and Hohle (12) and, in another context, by Brackbill, et al. (2). Prolonged redundant stimulation, independent of modality, decreases infant activity and attentional orientation (6, 11). One is tempted to postulate with Brazelton (3) some central nervous device which monitors certain general input parameters. When redundancy is sufficiently intense, and channel capacity limited, the signal-to-noise ratio decreases and sensory-behavioral contingencies obtain a potential instability. Since such instability is, by definition, disruptive of system organization and, in a general way, nonadaptive, it is not surprising some damping device is engaged. The maternal practices of rocking, patting, stroking, cooing, singing, and feeding probably overdetermine infant quiescence through what appears a very general stimulus control mechanism. Redundancy, even redundant love, inhibits as well as soothes.



## D. Analysis 2: Twin Differences

### 1. Results

A five factor ANOVA of difference scores by trials between pairs of twins was computed. The first four factors, A through D, were the same as the factors in the preceding analysis. The fifth factor was twin zygosity with subjects classed as fraternal or identical. Significance for main effects and interactions was again set at or beyond the .01 level of confidence.

Four interactions obtained significance (Table 2). Differences between

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Insert Table 2 about here

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twins were either unchanged or somewhat smaller after slow treatments, but larger after fast treatments relative to initial state (BC interaction). The activity of fraternal twins diverged during the slow rocker treatments, particularly during the no sound condition (ABCE interaction), and after fast rocker treatments (BCE interaction, Figure 2). Finally, difference scores for

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Insert Figure 2 about here

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fraternal twins were more variable by trials to the various treatments (ABDE interaction, Figure 3).

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Insert Figure 3 about here

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## 2. Discussion

Three of the four significant interactions involved behavioral divergence between fraternal and identical twins. In contrast to the behavioral consistency and stability of identical twins, fraternal twins were more divergent under all treatment conditions and markedly more variable in this divergence.

The fast rockerbox treatments as well as the sound condition tended to suppress fraternal divergence and variability during treatment. The reduced divergence derived from at least two sources: first, the treatments affected the majority of subjects in a uniform way (toward greater quiescence); and second, ratings were clustered about a basal level which, ipso facto, reduced possible variation.

In contrast to the similarity of fraternal behavior during "stronger" treatment, fraternal divergence increased after fast treatments when the rocker action had ceased (Figure 2). This divergence accompanied recovery toward initial state after the "enforced" convergence associated with strong treatment. Treatment and post-treatment fraternal divergence appeared reciprocally related. This association was, in part, a product of the differences in rate of adjustment after enforced deviation from a characteristic (pre-treatment) state. Less profoundly, individual behavior was free to vary when not constrained.

Within the constraints imposed by a small n (characteristic of twin studies), these results implicate a constitutional contribution to infant response to redundant proprioceptive and auditory stimulation. Not only the general state obtained by the infant but also the pattern and duration of recovery appear intrinsically mediated. These action patterns are quite "molecular" insofar as they describe the simultaneous response of twin pairs within relatively brief time intervals. As suggested by Freedman (4, 5) the genetic basis of behavior appears to extend to specific reactions to specific stimuli.

E. Summary

A review of the literature implies redundant proprioceptive and auditory stimulation are associated with changes in infant state which appear bio-physically linked and relatively independent of reinforcement history (2, 12, 15). In the present investigation, the concurrent behavior of three sets of fraternal twins and six sets of identical twins to four combinations of proprioceptive and auditory treatments was evaluated to provide evidence about the role of genetic factors in regulation of response to redundant stimulation. Group evaluation, without regard to zygosity, replicated the general effectiveness of proprioceptive stimulation and suggested the occurrence of a gradual recovery period after treatment. In general, recovery was less pronounced for initially more active infants. Moreover, continuous sound stimulation augmented the proprioceptive treatment. When difference scores between groups were evaluated for treatment combinations, identical twins obtained a marked behavioral consistency from pre- through post-treatment periods. Fraternal twins were significantly more divergent during the weaker, slow, no sound condition and after the stronger, fast conditions as well as significantly more variable in behavior within periods. The results appear to provide positive evidence for the role of endogenous, genetically linked regulation of infant response to redundant stimulation.

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## Footnotes

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[2]On leave from the University of Illinois. At present, special USPHS Fellow.

[3]Redundancy describes a parameter of information transmission. A completely repetitive signal supplies no new information and, in this sense, is analogous to a completely noisy channel with no code transmission. In both cases, relative entropy is zero.

Table 1

ANOVA for Treatment Effects

| Source | MS | df | F | p |
|---|---|---|---|---|
| Between subjects | 16.36 | 15 | | |
| Within subjects | 1.33 | 368 | | |
| A (sound) | 3.89 | 1 | 4.80 | n.s. |
| e | .81 | 15 | | |
| B (rate) | 2.22 | 1 | 1.33 | n.s. |
| e | 1.67 | 15 | | |
| C (intervals) | 68.26 | 2 | 65.61 | < .001 |
| e | 1.04 | 78 | | |
| D (trials) | 2.27 | 3 | 6.39 | < .01 |
| e | .35 | 75 | | |
| AB | 2.22 | 1 | 2.47 | n.s. |
| e | .89 | 15 | | |
| AC | 1.81 | 2 | 5.11 | < .01 |
| e | .36 | 78 | | |
| AD | .23 | 3 | < 1.00 | n.s. |
| e | .28 | 75 | | |
| BC | 1.40 | 2 | 3.05 | n.s. |
| e | .45 | 78 | | |
| BD | .73 | 3 | 4.00 | n.s. |
| e | .18 | 75 | | |
| ABC | .34 | 2 | < 1.00 | n.s. |
| e | .67 | 78 | | |
| ABD | .14 | 3 | < 1.00 | n.s. |
| e | .24 | 75 | | |

Table 2

ANOVA for Difference Scores

| Source | MS | df | F | p |
|---|---|---|---|---|
| Between pairs | 7.69 | 6 | | |
| F (groups) | 22.69 | 1 | 4.83 | n.s. |
| e | 4.69 | 5 | | |
| Within pairs | .58 | 161 | | |
| A (sound) | .01 | 1 | < 1.00 | n.s. |
| AE | 3.17 | 1 | 4.70 | n.s. |
| e | .67 | 5 | | |
| B (rate) | .04 | 1 | < 1.00 | n.s. |
| BE | .18 | 1 | < 1.00 | n.s. |
| e | .23 | 5 | | |
| C (intervals) | 1.05 | 2 | 3.72 | n.s. |
| CE | .13 | 2 | < 1.00 | n.s. |
| e | .28 | 31 | | |
| D (trials) | .38 | 3 | < 1.00 | n.s. |
| DE | .06 | 3 | < 1.00 | n.s. |
| e | .40 | 25 | | |
| AB | 1.33 | 1 | 4.52 | n.s. |
| ABE | 2.22 | 1 | 7.52 | n.s. |
| e | .29 | 5 | | |

Table 2 (cont'd)

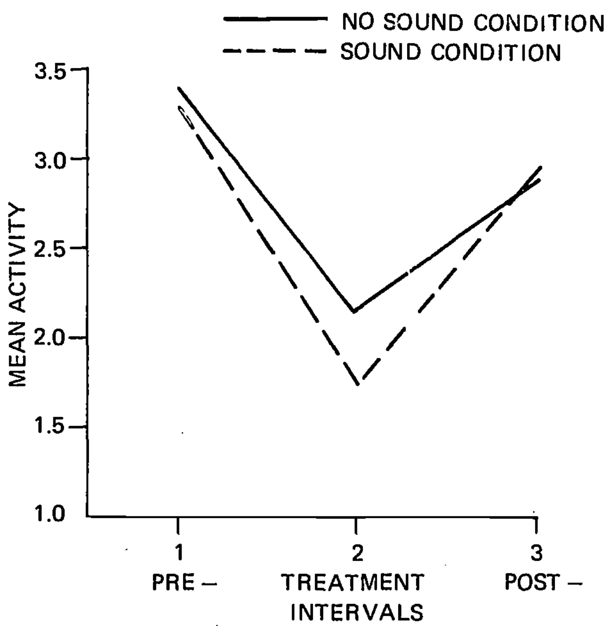
| Source | MS | df | F | p |
|---|---|---|---|---|
| AC | 1.13 | 2 | 5.13 | n.s. |
| ACE | .37 | 2 | 1.72 | n.s. |
| e | .22 | 31 | | |
| AD | .27 | 3 | 1.06 | n.s. |
| ADE | .70 | 3 | 2.74 | n.s. |
| e | .25 | 25 | | |
| BC | 1.55 | 2 | 7.10 | < .01 |
| BCE | 6.04 | 2 | 27.61 | < .001 |
| e | .21 | 31 | | |
| BD | .34 | 3 | 3.44 | n.s. |
| BDE | .27 | 3 | 2.69 | n.s. |
| e | .10 | 25 | | |
| ABC | .07 | 2 | 1.12 | n.s. |
| ABCE | .57 | 2 | 8.68 | < .01 |
| e | .06 | 31 | | |
| ABD | .38 | 3 | 3.27 | n.s. |
| ABDE | 2.09 | 3 | 17.83 | < .001 |
| e | .11 | 25 | | |

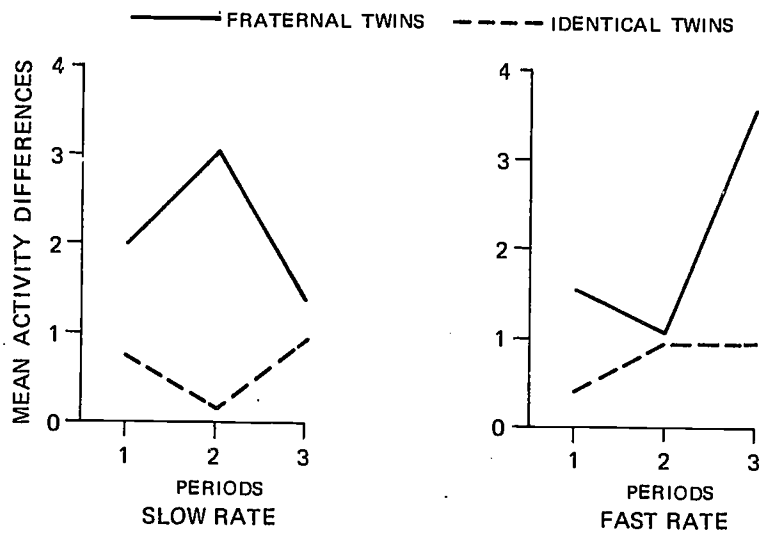
Figure Captions

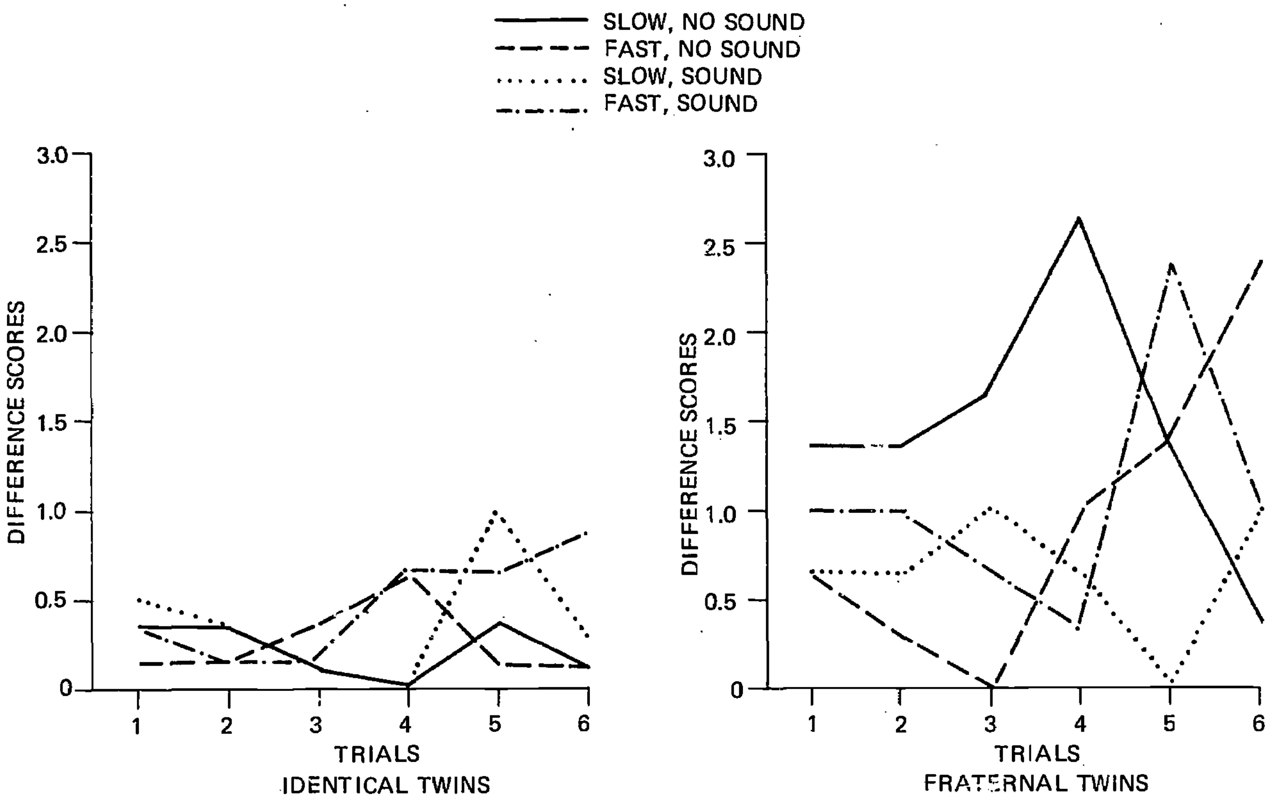
Figure 1. Mean activity by periods for sound and no sound conditions.

Figure 2. Difference scores for identical and fraternal twins by periods for slow and fast rockerbox treatments.

Figure 3. Treatments by trials by groups. Fraternal twin pairs are not only less concordant for behavior than identical pairs but more variable from trial to trial.


NO SOUND CONDITION
SOUND CONDITION
3.5
3.0
2.5
2.0
1.5
1.0
MEAN ACTIVITY
1
2
3
PRE –
TREATMENT
POST –
INTERVALS


FRATERNAL TWINS
IDENTICAL TWINS
MEAN ACTIVITY DIFFERENCES
4
3
2
1
0
1
2
3
PERIODS
SLOW RATE
4
3
2
1
0
1
2
3
PERIODS
FAST RATE


SLOW, NO SOUND
FAST, NO SOUND
SLOW, SOUND
FAST, SOUND
3.0
2.5
2.0
1.5
1.0
0.5
0
DIFFERENCE SCORES
1
2
3
4
5
6
TRIALS
IDENTICAL TWINS
3.0
2.5
2.0
1.5
1.0
0.5
0
DIFFERENCE SCORES
1
2
3
4
5
6
TRIALS
FRATERNAL TWINS