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ABSTRACT

The Infant Health and Development Program (IHDP), an eight-site randomized controlled trial of a comprehensive intervention program combining home visits, child centers, and parent meetings with pediatric follow-up and referral, effectively reduced the incidence of health and developmental problems in a sample of 377 low birth weight, premature infants when compared to a control group of 608 infants during the first 3 years of life. This secondary study examined the relationship between participation in the IHDP and IQ, both at individual time points and for the developmental course of intelligence. At 12 months of age, no relationship between participation and IQ was evident, while at 24 months higher IQ was associated with increased levels of participation in years 1 and 2 of the study. At 36 months of age higher IQ was associated with increased levels of participation in all 3 years of the study. These relationships existed even after taking into account aspects of children's pre-intervention status known to be associated with intellectual development. These results are interpreted as providing support for the idea that the quality and type of experience gained in the first 3 years of life are of major importance for developing cognitive abilities. (Author/MDM)

Early Intervention for Low Birth Weight, Premature Infants: Participation and Intellectual Development

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Running head: PARTICIPATION AND INTELLECTUAL DEVELOPMENT

ABSTRACT

The Infant Health and Development Program (IHDP), an eight-site randomized controlled trial of a comprehensive intervention combining home visits, child centers and parent meetings with pediatric follow-up and referral, effectively reduced the incidence of health and developmental problems in a sample of low birth weight, premature infants during the first three years of life. This secondary analysis examined the relationship between participation in the intervention and IQ, both at individual time points and for the developmental course of intelligence. At 12 months, no relationship between participation and IQ was evident, while at 24 months, higher IQ was associated with increased levels of participation in Years 1 and 2 of the study. At 36 months, higher IQ was associated with increased levels of participation in all 3 years of the study. These relationships exist while taking into account aspects of children's pre-intervention status known to be associated with intellectual development. In the longitudinal analysis of these data, it was found that the intellectual development of children in the intervention group was associated with all 3 intervention modalities, the number of days attended at child centers, the number of home visits received, and the number of parent meetings attended. Children's pre-intervention status failed to significantly predict intellectual development over the 3 years of the study. These results are interpreted as providing support for the idea that the quality and type of experience gained in the first three years of life are of major importance for developing cognitive abilities.

Early Intervention for Low Birth Weight, Premature Infants: Participation and Intellectual Development

Two important principles in the study of early educational interventions with disadvantaged children and families are timing and intensity. Scientific results concerning timing and intensity are clear: high quality, intensive educational efforts beginning early in life demonstrate greater cognitive gains among experimental group participants than do programs that are either less intense or begin later in life (Ramey & Ramey, 1992). Among the educational intervention efforts that have demonstrated large positive effects on the cognitive development of preschoolers are the Abecedarian Project (Ramey, Bryant, Campbell, Sparling, & Wasik, 1988), The Brookline Early Education Project (Hauser-Cram, Pierson, Walker, & Tivnan, 1991), the Milwaukee Project (Garber, 1988), Project CARE (Wasik, Ramey, Bryant, & Sparling, 1990), and the Infant Health and Development Program (IHDP, 1990).

The Infant Health and Development Program for low birth weight, premature infants (IHDP) demonstrated the efficacy of an intervention combining pediatric follow-up with family support through home visits, full-day, five-day per week child development centers, and parent support through group meetings. The intensity, or regularity of the intervention was positively related to intellectual development at 36 months as the probability of borderline mental functioning decreased with increasing levels of participation. This significant positive relationship between amount of participation in the intervention and 36 month Stanford-Binet IQ exists while taking

into account social, economic, health status, and demographic variables known to be associated with intellectual development (Ramey, Bryant, Wasik, Sparling, Fendt, & LaVange, 1992). This finding presents the opportunity for this examination of the developmental course of the relationship between participation in the intervention and intellectual development over the first three years of life.

The framework for examining the relationship between participation and intervention effectiveness emphasizes the importance of reciprocal interactions between infants and caregivers. It takes the perspective that when interactions are appropriately matched to developing intellectual structures in the child, cognitive development is maximized. The underlying assumption is that regular, developmentally appropriate interactions between caregivers and children are necessary for normal development. The philosophy guiding the delivery of the IHDP intervention is one that emphasized the ability of children to make choices and to actively structure a part of their own activities. The intervention was designed to foster children's sense of self, incorporating the assumption that a warm and supportive environment which allows children room for self-expression will enhance development (Bryant, Ramey, Sparling, & Wasik, in press).

This investigation addresses the concepts of timing and intensity in early intervention by examining the relationship between the amount of the intervention received and IQ at different time points. It is important to note that the association between early learning experiences and cognitive gains in no way indicates an upper

critical period boundary beyond which intervention efforts may be ineffective. The emphasis here is on determining at what age the association between educational intervention and IQ is evident and how the amount of intervention received at a given time relates to IQ at 12, 24, and 36 months of age. Previous analyses of these data indicated a linear relationship between participation and IQ at 36 months of age. But how this relationship is expressed in the developmental course of intelligence is of interest. Is the linear relationship between participation and IQ present at the 12 and 24 month assessments, or does early intervention express itself only at 36 months, after three years of intervention services have been provided? This is an important question of relevance not only for program evaluators and policy makers, but for the light it may shed on understanding the course of intellectual development over the first 3 years of life.

The hypothesis considered here was that participation in the intervention would be linearly related to IQ at each assessment point. Further, the present analysis sought to determine if cognitive gains resulting from the IHDP intervention would be associated only with sustained high levels of participation in all 3 intervention modalities across all 3 years of the study. It was hypothesized that higher levels of participation (both across time and across modalities of the intervention) would be associated with positive cognitive gains.

Method

Subjects

Over an eight month period between January 7, 1985 and October 9, 1985, families of low birth weight ($\leq$ 2500 grams) premature infants ($\leq$ 37 weeks gestation) were recruited by eight medical institutions to participate in a randomized, controlled trial of an early intervention program. Families were contacted and recruited during the infants' stay in the neonatal nursery and intervention began immediately after discharge from the hospital. The intervention was conducted until the youngest child at each site reached 36 months of age corrected for prematurity. All ages reported in this study refer to ages corrected for degree of prematurity (that is by subtracting the child's degree of prematurity from his or her chronological age).

There were 377 infants in the Intervention group and 608 in the Follow-up (contr l) group. These 985 infants constitute the primary analysis group. All infants were randomly assigned and a procedure was implemented to monitor enrollment, ensuring that the two groups were balanced for birth weight, gender, maternal age, maternal education, and maternal ethnicity. Three-quarters of families eligible for enrollment in the study were successfully recruited and all but 7% of study participants remained in the study until 36 months of age. Eligible families who chose not to enroll in the study did not differ from those who enrolled in terms of mother's age or single versus twin birth status. They were more likely to be white and to be from one of the eight sites. Families varied widely on initial status characteristics

(mother's age, mother's education, birth weight, neonatal health status). Approximately half of the infants were male, 53% of the sample were African American, 10% were Hispanic, and the remaining 37% were White, Asian, or Other. The typical infant enrolled in this study weighed 1800 grams and was of 33 weeks gestational age.

Procedure

In order to address the primary research question concerning the effectiveness of combining a home visiting program, comprehensive child development centers, and parent support through group meetings, both the Intervention and Follow-up groups were provided with pediatric monitoring and referral. The pediatric follow-up protocol consisted of eight medical, developmental, and social assessments conducted between 40 weeks and 36 months corrected age. Standardized interviews were conducted in which mothers reported on their children's health and developmental functioning, and social and demographic information was obtained. IHDP staff made referrals as necessary and helped families obtain recommended services.

For the Intervention group, home visits occurred weekly following hospital discharge until 12 months corrected age, and occurred twice monthly from 12 months until 36 months corrected age. The visits were designed to assist parents in learning specific ways to foster their child's social, intellectual, and physical development by providing them with information as well as practical support. A curriculum for very young low birth weight infants, Early Partners (Sparling, Lewis, & Neuwirth, in

press), and a curriculum for infancy and early childhood, Partners for Learning (Sparling & Lewis, 1984) were introduced by the home visitors. Together, the home visitors and the parents selected appropriate activities for the child.

Attendance at child development centers began at 12 months corrected age and continued through 36 months corrected age. The centers operated full day, five days per week, 50 weeks per year. The same curriculum implemented in the home visits was utilized in the child centers, and home visitors served to coordinate the use of the curriculum at home and in the center. Transportation was provided for children who needed it.

Parent group meetings occurred every other month from 12 months corrected age until 36 months corrected age. The meetings functioned as support groups in which parents could share information and concerns. Also, the meetings were organized around special topics in child development and community resources. Transportation and child care services were provided and meals were often included in the meetings.

Of the 377 families and infants in the Intervention group, 371 received home visits (98%), 325 attended the child development centers (86%), and 294 attended the parent group meetings (78%). In the intervention as a whole, a mean of 67 home visits were made (median = 73, range 0-100), children attended an average of 267 child center days (median = 326, range 0-468), and parents attended a mean of 3.7 meetings (median = 3, range 0-12). Further information on intervention content and

procedure can be obtained from Ramey et al. (1992).

Measures

Children's intellectual development assessed at three time points, 12, 24, and 36 months of age was the primary outcome measure for this study. The Bayley Scales of Infant Development were administered at 12 and 24 months of age, and the Stanford-Binet Intelligence Scale, Form L-M, 3rd Edition was administered at 36 months of age. Of the 985 children in the study, 549 Follow-up and 344 Intervention subjects were assessed at 12 months, 526 Follow-up and 336 Intervention subjects were assessed at 24 months, and 561 Follow-up and 347 Intervention subjects were assessed at 36 months.

Data analysis

A repeated measures analysis of variance was conducted to compare the intellectual development of those receiving the intervention to those receiving only the pediatric follow-up at the three assessment points. Following this, initial status variables (maternal ethnicity, sex of child, maternal education, birth weight, maternal age, neonatal health status, and site) plus group membership, were used to predict 12 and 24 month IQ. Further, the interaction of group membership with each initial status variable was also tested for the 12 and 24 month data, while controlling for all other variables (36 month data previously reported in IHDP, 1990).

For the second and third years of the study, an index of participation was created for each Intervention group member by combining the number of home visits

received, the number of days attended at the child development centers, and the number of parent group meetings attended into a composite score. For Year 1 of the study, home visiting was the sole intervention modality so it alone serves as the index of participation in the analysis of the first year data. The rationale for creating a single participation variable was that intervention efficacy was conceptualized as the cumulative impact of the modalities rather than the separate contribution of each to child outcome; no a priori hypotheses existed concerning the efficacy of a particular intervention modality. Participation variables were residualized using the Gram-Schmidt procedure, in which shared variance among the participation variables for each year of the study was removed. The test of participation in Year 2 represents only variance not shared with Year 1 participation, and the test of participation in Year 3 represents only variance not shared with Years 1 and 2 of the study. To assess the relationship between participation, initial status variables, and outcome, multiple regression analyses were conducted for the Intervention group members only. For purposes of illustrating the relationship between participation and IQ over time and in order to test the level of participation relative to controls, a categorical level participation variable was created for each year of the study by dividing the index of participation into high, medium, low, and control group categories. All Intervention group subjects are included in either the high, medium, or low categories. Categorical participation was tested for the 12, 24, and 36 month assessments. All follow-up tests were conducted using Tukey's studentized range test. Further analysis of participation

was conducted by examining the correlation within each modality for the three years of the study and between modalities for years 2 and 3. Finally, a generalized estimating equation (GEE) was used to examine the relationship between intellectual development over the course of the intervention and participation in the individual intervention modalities, as well as the initial status variables. The GEE is an extension of the general linear model applicable to longitudinal data. The GEE accounts for correlation between repeated measures by specifying a correlation matrix (in this case exchangeable) for the observations of each subject. The resulting linear model provides consistent estimators of the regression co-efficients and their standard errors under weak assumptions about the correlation present in a given subjects observations (Zeger & Liang, 1986; Zeger, Liang, & Albert, 1988). The scientific emphasis is on the regression relationship between the outcome variable and the covariates while accounting for the correlation among the repeated observations for a given subject. The purpose of the GEE here, is to compare intellectual development among subjects with differing levels of participation in the intervention.

Results

As shown in figure 1, the repeated measures analysis of variance revealed a significant main effect on IQ for group (Intervention vs. Follow-up) $F(1,830)=37.99$, $p<.0001$, a significant main effect for time $F(2,1660)=501.94$, $p<.0001$, and a significant group by time interaction $F(2,1660)=40.33$, $p<.0001$.

Insert figure 1 about here

At 12 months, initial status variables along with group membership accounted for 23% of the variance in Bayley MDI $F(18,874)=14.41$, $p<.0001$ (see Table 1). Significant effects were obtained for all variables except group membership. Follow-up analyses of this regression indicated that African Americans scored below both Hispanic and White\Asian\Other, while the children of mothers with college degrees or some college scored higher than children of mothers with some high school. Analyzing all sites relative to an arbitrarily designated comparison site, Yale, it was found that the children at the Arkansas, Harvard, Pennsylvania, and Washington sites scored significantly higher than did those at Yale, while the children at the Miami site were lower. Also, boys scored significantly lower than girls and neonatal health status (with high scores representing good health) and birth weight were positively related to IQ, while mother's age was negatively related to 12 month score on the Bayley. None of the interactions between group membership and participation reached significance.

The block of initial status variables including group membership accounted for 35% of the variance in 24 month Bayley IQ $F(18,843)=25.45$, $p<.0001$. Significant effects were obtained for all variables except maternal age. Follow-up analyses of these results indicated that African American children scored significantly higher than did Hispanic children and that White\Asian\Other children scored significantly higher

than did both African American and Hispanic children. The children of mothers with a high school degree scored higher than did those whose mothers had some high school. Children of mothers with some college scored higher than did those whose mothers had a high school degree or some high school, but were not significantly different from those children whose mothers had less than a 9th grade education. Children of mothers with a college degree or more scored higher than did children in all other groups. Analyzing all sites relative to the comparison site, Yale, it was found that the children at the Harvard and Texas sites scored higher than did those at Yale, while children at the Miami and Einstein sites scored lower than did those at Yale. Also, boys scored significantly lower than did girls, and birth weight and neonatal health status were positively related to IQ at 24 months.

Significant interactions between the intervention and maternal education $F(4,826)=2.49$, $p<.05$, birth weight $F(1,826)=4.93$, $p<.05$, and mother's ethnicity $F(2,826)=5.17$, $p<.01$, indicated that the children of college educated mothers in both the Intervention and Follow-up groups scored at comparable levels whereas there were significantly greater differences for infants whose mothers were less well educated. Also, results indicated that the intervention was more effective for heavier infants, and that the effectiveness of the intervention was reduced for the White\Asian\Other children. Figure 2 illustrates the interaction between mother's education level and group membership. Because the number of mothers with less than a 9th grade education (18) was small, these subjects were combined with those having

completed some high school (grades 9 -11). It can be seen that for children of college educated mothers, there was no treatment effect.

Insert figure 2 about here

Table 2 presents the descriptive statistics for cumulative participation and for participation by year and modality of the intervention. The results for the regression containing the number of home visits received in the first 12 months of life are presented in Table 3. Variance accounted for by participation in the intervention did not significantly add to the prediction of 12 month IQ. Figure 3 illustrates this relationship by dividing participation into high, medium, low, and control group categories; higher 12 month IQ within the treatment group was not related to the amount of the intervention

received.

Insert figure 3 about here

Also in Table 3, the results for the regression containing participation variables indicated that at 24 months of age, higher IQ in the Intervention group was associated with the number of home visits received in the first year $F(1,316)=5.98$, $p < .05$ and with the cumulative index of participation in the second year of the study

(the sum of home visits received in the second year, the number of days attended at child centers in the second year, and the number of parent group meetings attended in the second year) $F(1,316) = 17.22$, $p < .0001$. Figure 3 also illustrates the relationships between categorical level of participation in second year of the study and IQ at 24 months of age.

The results for the 36 month data on initial status variables and cumulative participation summed over the 3 years of the study have been previously reported (IHDP, 1990; Ramey et al., 1992). For this analysis, higher IQ at 36 months was associated with the number of home visits received in the first year of the study, $F(1,326) = 8.01$, $p < .005$, with cumulative participation in the second year of the study, $F(1,326) = 14.15$, $p < .0005$, and with cumulative participation in the third year of the study, $F(1,326) = 6.37$, $p < .05$ (see Table 3). Figure 3 also illustrates the relationship between categorical level of participation in the third year of the study and IQ at 36 months.

Higher IQ is associated with higher participation at 24 and 36 months. In order to illustrate the relationship between participation and IQ over the 3 years of the study, participants were divided into high, medium and low participation groups. Members of the high participation group were those subjects who displayed a high level of participation at each assessment, 12, 24, and 36 months. The medium group consists of subjects who were at a high or medium level at any assessment point, and the low participation group consists of subjects who exhibited low participation at any

assessment point. The test of level of participation addresses the question of whether or not sustained, high levels of participation across the 3 years of the IHDP result in significant cognitive gains when compared with lesser participation. Of the 328 Intervention group children with an IQ measure at each time point, over one-third, 142 were in the high participant group at each assessment point. Table 4 provides the means and standard deviations for these groups on each of the participation variables for the individual modalities of the intervention and for IQ at 12, 24, and 36 months. It can be seen that the high participation group is higher on all participation variables. Figure 6 illustrates the relationship between change in level of participation and IQ over the course of the study. This graph indicates that those subjects receiving high levels of the intervention exhibited higher IQ at the 12, 24, and 36 month assessments than did those receiving lower levels of the intervention.

For the IQ measures, follow-up analyses revealed that at 12 months, the groups were not significantly different. At 24 months the high and medium participant groups were significantly higher than the low participant group but not from each other. At 36 months, the high participant group scored significantly higher than did the medium and low groups, which were not significantly different from each other. For the participation variables, follow-up analyses indicated that the participation groups were significantly different from each other on the number of home visits received in Year 1, the number of child center days and parent group meetings attended in Year 2, and the number of child center days attended in Year 3. The high

and medium groups did not differ in the number of home visits received in Years 2 and 3, or in the number of parent group meetings attended in Year 3; both were significantly different from the low participant group on these variables.

Insert figure 4 about here

From these analyses it appears that higher IQ at 24 and 36 months is associated with higher levels of participation during all 3 years of the study in most, but not all, intervention modalities. While the data present an orderly picture of the relationship between participation and IQ, there are still some unanswered questions concerning participation in the IHDP. It is possible for a subject to have received only the child center component of the intervention in Year 2 and to have been in the high participation group. Again, because child center attendance composes the bulk of the participation variable, it is possible for a child to have received only the child center component again in Year 3 and to have been in the high participant group. This possibility certainly does not fit with the rationale behind the IHDP intervention, and it is necessary to look at the relationships among participation variables in an attempt to determine if particular aspects of the intervention are accounting for the relationship between cumulative participation and IQ.

Correlational analysis of participation in the three intervention modalities indicated that the amount of the intervention which children and families received

remained moderately stable over time. Those families who participated at high levels in Year 2 of the study remained high in Year 3 (r=.88). Those families receiving high levels of home visits in Year 1 of the study tended to participate at high levels in Year 2 (r=.50) and in Year 3 (r=.46). These moderate to high correlations indicate that children and families tended to remain at a given level of participation over the course of the study. Over the 3 years of the study (see Table 5), correlations between the three intervention modalities (ie. home visits in Year 1 with attendance at parent group meetings in Year 3) ranged from .30 to .69. Correlations within the individual modalities of the intervention over the 3 years of the study (ie. home visits in Year 1 with home visits in Year 2), were slightly higher, ranging from .54 to .88. It appears that variability in participation exists primarily between modalities (some people participating in one aspect of the intervention while participating not at all in another) rather than within modalities over time.

Correlations in the moderate range between participation variables indicate that people were participating differentially in the intervention modalities. The possibility that a participant could be in the high participation group solely on the basis of child center attendance should be addressed through an analysis of the individual modalities of the intervention. Table 6 presents the estimates and standard error of the estimates derived from the generalized estimating equation used to predict intellectual development over the course of the 3 years of the IHDP intervention. Robust Z-test values greater than an absolute value of 1.96 indicate significance. The

significant parameters for time, the number of home visits received, days attended at child development centers, and suprisingly, a negative relationship between parent group meetings attended and IQ, indicate that these variables significantly predict intellectual development among intervention group members across the 3 years of the study. All initial status variables failed to significantly account for change in IQ over the 3 years of the study.

Discussion

The results of these analyses indicated that infants receiving early educational intervention exhibited cognitive gains when compared with the intellectual development of a control group. Two sets of results were presented, one for cross-sectional time points, or "snapshots" of intellectual development at 12, 24, and 36 months of age, and one for a longitudinal analysis examining the developmental course of intelligence over the 3 years of the intervention as a function of participation.

For the cross-sectional results, the multiple regression analyses revealed that at 12 months of age, children in the intervention and control groups exhibited similarly high scores on the Bayley MDI. At 24 months of age, higher IQ as measured by the Bayley MDI was associated with the number of home visits received in the first year of the intervention and with the amount of cumulative participation in the second year. Those children receiving high levels of home visits in the first year of life and a high level of the combination of home visits, child center days, and

parent group meetings in the second year, exhibited higher IQ than did children receiving lesser amounts, and controls. At 36 months of age, higher scores on the Stanford-Binet were associated with the number of home visits received in the first year of the study, cumulative participation in the second year of the study, and cumulative participation in the third year of the study.

The hypothesis that a linear relationship between participation and IQ would be evident at each assessment point has not found support. At 12 months there is no detectable difference between Intervention and Follow-up group IQ, and variance accounted for by the amount of the intervention received is not significant. Participation in the first year of the study is a significant predictor of 24 and 36 month IQ when participation in the second and third years of the study are summed into a cumulative index. It may be that the 12 month Bayley is not sensitive to the content of the intervention over the first year of life, or it may be that the benefits gained from educational intervention in the first year of life are expressed only as both cognitive maturation and intervention efforts proceed. In light of the analysis conducted here, the 12 month data, in addition to underscoring the initial equivalence of groups, may best be interpreted in light of the cumulative effect of the intervention on IQ. Those children receiving high levels of home visiting in the first year of the intervention were in a position to maximally benefit from the intervention at 24 and 36 month assessments.

Also, the expectation that higher IQ would be associated only with high levels

of participation in all 3 modalities of the intervention over the 3 years of the study failed to obtain support. When the relationship between participation and IQ is examined over the 3 years of the study, it is seen that those children receiving increased levels of the intervention in each year of the study displayed significant cognitive gains at 24 and 36 months compared to those receiving lesser amounts and controls, but that the relationship between IQ and participation in the individual intervention modalities varied.

For the longitudinal analysis, the results of the generalized estimating equation strongly suggest that the intervention had a large, positive impact on young children's cognitive development. While the initial status variables predict differences in IQ at individual points in time, the longitudinal analysis revealed that participation in the intervention, not pre-intervention status, was accounting for differences in intellectual development over the 3 years of the study. The longitudinal analysis revealed that each of the individual intervention modalities was significantly related to intellectual development. The negative relationship between parent group meeting attendance and intellectual development is unexpected and the reliablity of this finding may be questionable. There were only 12 parent meetings during the course of the study and the expectation that an effect would be observed from such a small but conceptually valid aspect of the intervention appears to have been unrealistic.

These results provide support for the hypothesis that the quality and type of experience gained in the first, second, and third years of life are of major, if not

critical importance for the development of cognitive skills. Because level of participation in the intervention is a multiply determined phenomenon, no definitive conclusions can be made regarding the relationship between specific differences in participation and intervention effectiveness. It is possible that other unmeasured factors account for the relationship between participation and IQ, but the design of the IHDP reduces the likelihood of this possibility (Ramey et al., 1992). Given the results of the present analysis, efforts to increase participation which target the child, the parent, and increase the motivational and interpersonal aspects of the relationship between the parent and those responsible for the delivery of the intervention would be warranted.

These results support the expectation that higher IQ would be associated with high levels of sustained participation in all 3 intervention modalities, but this analysis has not been able to effectively address the issue of how change in an individual subject's participation over time affects the relationship between participation and IQ. It appears that level of participation did vary across the 3 years of the study, but how this relates to intellectual development is unclear because there are insufficient numbers of subjects displaying unique patterns of participation. Further analysis of participation in early interventions could investigate subject-specific models (Zeger, Liang, & Albert, 1988) in which an individual child's IQ could be modeled based upon changes in participation over time. This model would indicate how one child's IQ would change with changes in participation. Also, with regard to the timing and

intensity of intervention efforts, this analysis could not directly address questions about early versus late intervention or the efficacy of specific components or combinations of specific components of early intervention at different time points. These results indicate that high levels of participation during each year of the study are associated with higher IQ at 24 and 36 months. Further, these results indicate that an intervention which was both early and intense was effective in attenuating the IQ decline associated with the cognitive development of low birth weight, premature infants.

The analysis of cumulative participation indicates that the intervention delivered in the first year of life is associated with higher IQ at ages 2 and 3, but not at age 1. Further, cumulative participation in the intervention in Year 2 is predictive of Year 3 IQ. It is tempting to interpret these results as indicating a sensitive period phenomenon, that infants receiving early intervention are responding to environmental stimulation and are at an advantage with regard to later intellectual development. But the IHDP was designed as a comprehensive early intervention and questions about the efficacy of specific components of the intervention or about possible sensitive period effects, though addressable through intervention research cannot be addressed within the IHDP.

Remarkably, the relationship between intellectual development and participation in the IHDP exists independently of demographic measures known to be associated with IQ. This finding is apparently at odds with the finding both here and

in a separate analysis (Brooks-Gunn, Gross, Kraemer, Spiker, & Shapiro, 1992), that the intervention was differentially effective with certain subgroups of the population studied. When examining the follow-up and intervention groups combined, it was found that for the children of college educated mothers, no treatment effect was observed. One explanation would be that the control children in this subgroup were receiving care equivalent to that being provided in the intervention. Looking only at the intervention group, however, revealed that children receiving greater amounts of the intevention, regardless of mothers' educational level, exhibited more desirable developmental trajectories. It may be that early educational experience interacts with social and demographic risk factors in different ways, but these results suggest that early experience serves an important cognitive developmental function for all social and demographic backgrounds. It may not be a great equalizer, but these tentatively support the idea that early intervention can provide all children, whether facing difficult life circumstances or not, with an early advantage. Clearly, the combination of biologic and social risk cannot be entirely overcome, but here, as in other studies (Martin, Ramey, & Ramey, 1990; Breitmayer & Ramey, 1986), those most at-risk stand to make the greatest gains. The reduction or elimination of intergenerational low birth weight is one remote benefit that might be expected from early intervention programs. The importance of the low birth weight mother's own birth weight, of her childhood social and economic resources, and of the factors associated with intergenerational poverty (Emanuel, Hale, & Berg, 1986) all point to the idea that

efforts to reduce poor birth outcomes should begin as early in life as possible. Early preventive intervention may have demonstrable benefits for the health and psychological development of future generations.

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Table 1

Regression of IQ at 12 and 24 Months (Corrected Age) on Initial Status Variables and Group (Intervention vs. Pediatric Follow-up) Membership.

		12 month Bayley MDI		24 month Bayley MDI	
Source	DF	F Value	Pr > F	F Value	Pr > F
Sex	1	5.99	0.0146	14.44	0.0002
Maternal ethnicity	2	5.70	0.0035	32.47	0.0001
Birth weight	1	55.55	0.0001	10.88	0.0010
Maternal education	4	5.35	0.0003	14.28	0.0001
Maternal age	1	14.79	0.0001	0.00	0.9686
Neonatal health	1	18.38	0.0001	6.98	0.0084
Site	7	15.07	0.0001	5.88	0.0001
Group	1	0.05	0.8232	89.86	0.0001
Sex x group	1	1.80	0.1804	0.81	0.3694
Ethnicity x group	2	0.33	0.7181	5.17	0.0059
Birth weight x group	1	1.12	0.2892	4.93	0.0267
Education x group	4	0.95	0.4316	2.49	0.0420
Maternal age x group	1	0.21	0.6449	0.41	0.5241
Health x group	1	0.31	0.5785	0.28	0.5950
Site x group	7	0.28	0.9612	0.72	0.6554

Table 2

Descriptive Statistics for Year 1 Participation

Variable	N	Mean	Std Dev	Range
number of home visits made	377	33.99	10.21	0 - 51

Descriptive Statistics for Year 2 Participation

Variable	N	Mean	Std Dev	Range
attendance at child centers	377	132.46	76.31	0 - 235
number of home visits made	377	17.43	7.17	0 - 29
parent meetings attended	377	2.13	1.90	0 - 7

Descriptive Statistics for Year 3 Participation

Variable	N	Mean	Std Dev	Range
attendance at child centers	377	134.88	78.53	0 - 241
number of home visits made	377	15.36	7.36	0 - 26
parent meetings attended	377	1.58	1.74	0 - 6

Table 3

Regression of IQ at 12, 24, and 36 Months (Corrected Age) on Initial Status and Participation Variables.

		12 month Bayley MDI		24 month Bayley MDI		36 month Stanford-Binet	
Source	DF	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F
Sex	1	0.17	0.6773	11.47	0.0008	10.37	0.0014
Race	2	3.20	0.0421	6.56	0.0016	14.87	0.0001
Birth weight	1	25.60	0.0001	10.36	0.0014	15.09	0.0001
Maternal education	4	3.02	0.0182	4.62	0.0012	5.62	0.0002
Maternal age	1	3.82	0.0514	0.32	0.5727	0.04	0.8368
Neonatal health	1	8.47	0.0039	1.11	0.2926	5.53	0.0193
Site	7	6.98	0.0001	2.49	0.0166	2.67	0.0107
Home visits Year 1	1	0.93	0.3364	5.98	0.0151	8.01	0.0049
Participation Year 2	1	----	----	17.22	0.0001	14.15	0.0002
Participation Year 3	1	----	----	----	----	6.37	0.0121

Table 4

Means and Standard Deviations For Participation Subgroups for IQ and Participation Variables

IQ		12 month Bayley		24 month Bayley		36 month Stanford-Binet	
Subgroup	N	Mean	SD	Mean	SD	Mean	SD
high	142	110.75	15.65	107.08	16.27	97.73	16.56
medium	121	108.72	16.26	105.12	18.86	93.69	17.47
low	65	106.62	17.39	95.26	16.96	90.60	21.07
Home Visits		Year 1		Year 2		Year 3	
Subgroup	N	Mean	SD	Mean	SD	Mean	SD
high	142	39.45	4.49	20.18	3.20	18.92	3.13
medium	121	34.08	7.06	19.51	4.51	17.60	4.91
low	65	30.58	11.07	15.20	7.96	11.08	8.27
Child Center Attendance		Year 2		Year 3			
Subgroup	N	Mean	SD	Mean	SD		
high	142	193.61	18.29	198.82	17.66		
medium	121	148.87	37.69	152.50	35.84		
low	65	41.66	58.42	38.38	57.03		
Parent Meetings Attended		Year 2		Year 3			
Subgroup	N	Mean	SD	Mean	SD		
high	142	3.26	1.91	2.24	1.66		
medium	121	2.39	1.60	2.02	1.76		
low	65	0.67	1.08	0.24	0.75		

Underlined means are not significantly different.

Table 5

Correlations Between and Within Intervention Modalities For All 3 Years of the Intervention

	visy1	visy2	daysy2	pgmy2	visy3	daysy3	pgmy3	P2	P3
home visits Year 1	-								
home visits Year 2	.65	-							
child center Year 2	.47	.59	-						
parent group Year 2	.35	.40	.63	-					
home visits Year 3	.54	.78	.60	.42	-				
child center Year 3	.44	.57	.88	.57	.69	-			
parent groups Year 3	.30	.34	.46	.62	.45	.54	-		
Participation Year 2	.50	.64	.99	.64	.63	.88	.47	-	
Participation Year 3	.46	.61	.88	.58	.73	.99	.59	.88	-

Table 6

Summary of the Generalized Estimating Equation Analysis of IQ as a Function of Initial Status and Participation Variables Across the 3 Years of the Study.

Source	Estimates	Robust S.E.	Robust Z-test
Birth weight	0.004390	0.030385	0.144471
Maternal education	22.783790	13.348885	1.706794
Maternal age	-3.728094	2.362603	-1.577961
Sex of child	37.726803	23.421293	1.610791
Site	1.552692	5.257321	0.295339
Maternal ethnicity	6.069632	15.977387	0.379889
Neonatal health	0.167234	0.841870	0.198646
Time	3.465616	1.138861	3.043056*
Home visits	10.494344	1.595345	6.578104*
Child center	0.693458	0.157490	4.403190*
Parent group	-.678832	0.180307	-3.764873*

(* $p < .05$)

Figure captions

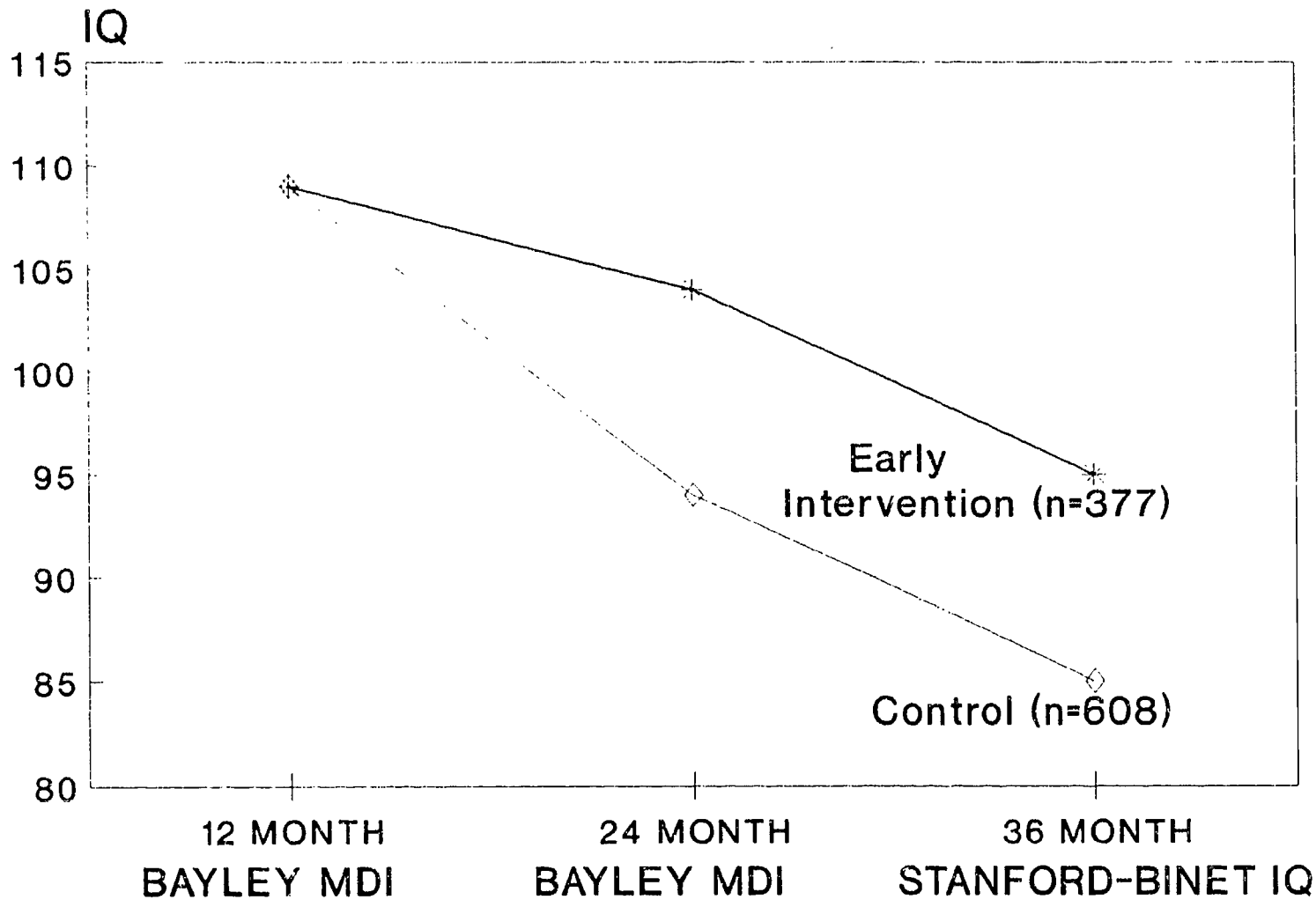
Figure 1 MDI and IQ as a function of early intervention for LBW premature infants

Figure 2 Twenty-four month MDI as a function of maternal education and group membership

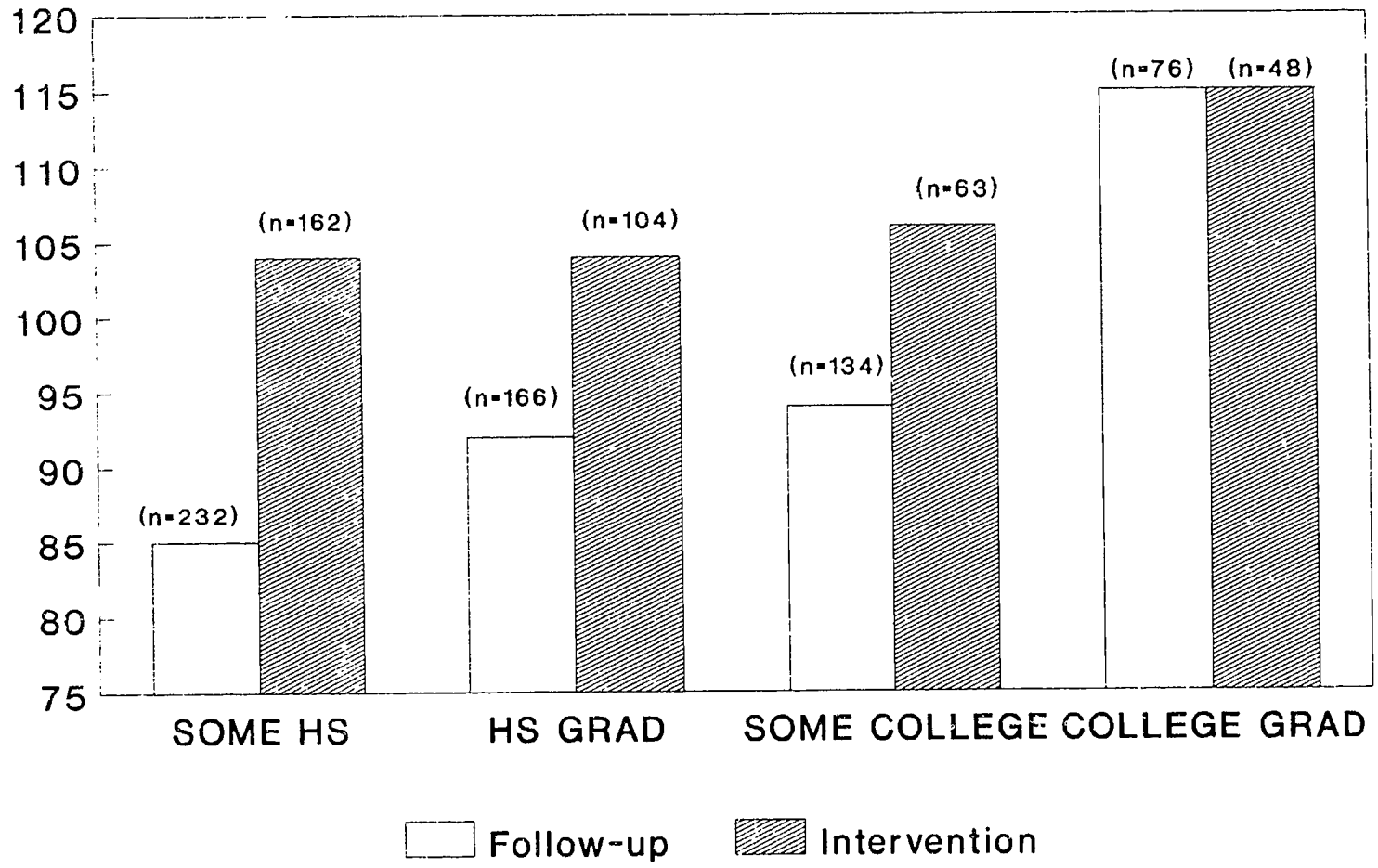
Figure 3 MDI and IQ as a function of level of participation in the intervention at 12, 24, and 36 months of age

Figure 4 MDI and IQ as a function of consistent level of participation in early intervention

MDI and IQ as a function of early intervention for LBW premature infants

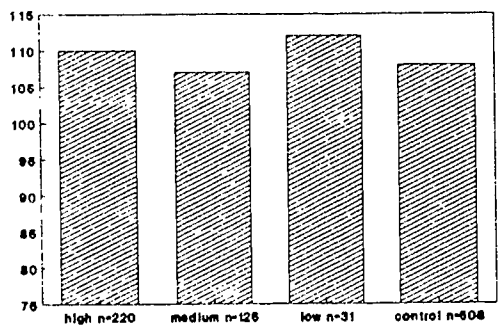


Twenty-four month MDI as a function of maternal education and group membership

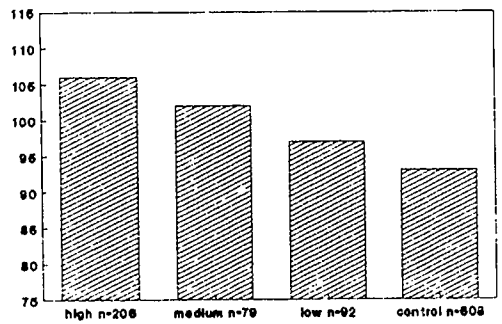


MDI and IQ as a function of level of participation at 12, 24, and 36 months of age

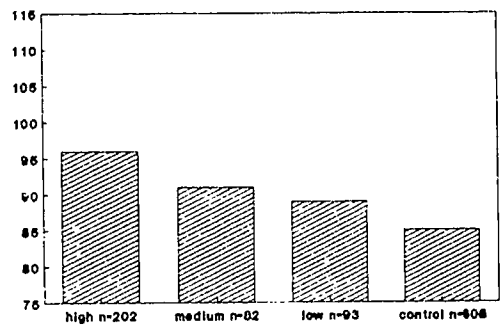
Twelve month Bayley MDI as a function of participation in Year 1



Twenty-four month Bayley MDI as a function of participation in Year 2



Thirty-six month Standford-Binet IQ as a function of participation in Year 3



MDI and IQ as a function of consistent level of participation in early intervention