THE RELATIVE IMPORTANCE OF PRENATAL PCB EXPOSURE, FEEDING TYPE, AND PARENTAL CHARACTERISTICS FOR COGNITIVE AND MOTOR DEVELOPMENT IN HEALTHY CHILDREN STUDIED FROM 3 TO 84 MONTHS OF AGE

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Introduction

Several prospective studies in normal populations of children give evidence of negative effects of prenatal polychlorinated biphenyl (PCB) exposure on cognitive and motor development. In the Dutch cohort, prenatal PCB exposure was related with lower psychomotor scores at 3 months of age[1], and lower cognitive abilities at 42 months of age[2]. Cognitive abilities at 3, 7, and 18 months and psychomotor abilities at 7 and 18 months of age[1] were not related with prenatal PCB exposure. At 84 months of age, negative effects of prenatal PCB exposure were seen in relation to maternal age at birth. In children born from younger mothers (18-25 years of age), prenatal PCB exposure was related with lower cognitive and motor abilities, whereas in children born from older mothers (25-39 years) no effect was seen. These groups of children were significantly different with respect to a number of variables likely to influence cognitive development; in the older group parental education level, parental verbal IQ, Home environment, and number of breast fed children were higher than in the group of children born from younger mothers. Prenatal PCB levels, however, were significantly higher in the group of children born from older mothers. These results clearly show the importance of background variables in studying subtle effects of prenatal PCB exposure on cognitive and motor development. Moreover, since evaluation of effects of prenatal PCB exposure on cognitive and motor development did not show consistent results over time, there is a need of longitudinal evaluation of the effects of prenatal PCB exposure on cognitive and motor development. The objective of this study was to identify and estimate relationships between prenatal PCB exposure, parental education level, parental verbal IQ, Home environment, type of feeding during infancy, and cognitive and motor development at 3, 7, 18, 42 and 84 months of age, using the method of structural equation modeling.

Methods and Materials

Subjects

207 healthy mother infant pairs, recruited in Rotterdam between June 1990 and February 1992, were invited to participate in cognitive and motor assessment from 3 to 84 months of age. 105 children were breast-fed and 102 were formula-fed during infancy.

Exposure variables

Prenatal PCB exposure was estimated from the sum of four PCB congeners (ΣPCB), International Union for Pure and Applied Chemistry (IUPAC) numbers 118, 138, 153, 180 in maternal plasma by gas chromatography with electron capture detection.

Background variables

The parental verbal IQ was assessed at 42 months by the subtests Information and Vocabulary, from the Wechsler Adult Intelligence scale (WAIS). The child's home environment was assessed by the Dutch version of the Home Observation for Measurement of the Environment (Home) at 18, 42, and 84 months of age (Home18, Home42, Home84). Additionally highest parental education level at birth and type of feeding during infancy (breast-fed or formula-fed) were included in these analyses.

Assessment of cognitive and motor development

Cognitive and motor development (CD and MD) were assessed at 3, 7, 18, 42, and 84 months of age with different test materials. The following scores were used as CD and MD variables.
The MDI and PDI of the Dutch version of the Bayley Scales of Infant development assessed at 3, 7 and 18 months of age were used as CD and MD variables at these time points. At 42 months the combined score of the sequential and simultaneous processing scales of the Dutch version of the Kaufman Assessment battery for Children (Dutch K-ABC) was used as CD variable. The sum of the standardised scores of the subtests gross and fine motor skills formed the MD variable at 42 months of age. At 84 months of age the general cognitive index (GCI) and the motor score of the Dutch version of the McCarthy Scales of Development formed respectively the CD and the MD variables.

Data analyses

The analyses for constructing structural equation models were conducted with the LISREL-8 program for Windows. Parameters were estimated by using the method of maximum likelihood, based on the correlation matrix of the observed variables. To explore structural relationships, the model generation method (MG) was applied. The general structural equation model incorporates both the measurement model and the structural model. In the measurement model each latent variable of the model is adequately represented by the respective observed variables without measurement errors. The structural model consists of direct and indirect relationships between independent and dependent, latent, variables.
ΣPCB levels were normalized by natural logarithmic transformation (lnΣPCB). It was assumed that the measurement error for the observed variable lnΣPCB was 0.1 of its variance, and the latent variable represented the observed variable without measurement error. The measurement error of feeding type was fixed at 0.0. A latent variable Education&Verbal IQ adequately represented the corresponding observed variables. The latent variable Home comprised the 3 observed Home environment variables (Home18, Home42 and Home84).
The process of fitting structural equation models started with creating a general latent variable for cognitive development (CD1) and motor development (MD1) from 3 to 84 months of age (Table 2. (1a)). This was done since relationships over time are more meaningful explained in terms of an underlying, more general, latent variable rather than as direct effects from one point of time to another[3]. Existence of specific latent cognitive and motor variables (CD2, MD2), nested in CD1 and MD1was identified (Table 2. (1b)). Subsequently, interdependency of cognitive and motor development was explored (Table 2. (2)). In the next step the independent variables, lnΣPCB, parental Education&Verbal IQ, Home environment, and feeding type were entered in the model. In Table 2. (3) the most plausible model was presented. Plausibility was based on theoretical knowledge on development, and statistical criteria. Statistical plausibility comprised the following

performance measures: (1) χ^2 (including degrees of freedom, and p-value): a nonsignificant value indicates that the model at issue cannot be rejected; (2) goodness-of-fit adjusted for degrees of freedom (AGFI), with a theoretical range from 0.0 (no fit at all) to 1.0 (perfect fit); (3) root-mean-squares error of approximation (RMSEA): a value of 0.05 indicates a close fit.
The covariances of the independent latent variables were estimated throughout the whole process of structural modeling.

Results and Discussion
Cognitive and motor development at all time points, and data on PCB exposure, parental education level, parental verbal IQ, and Home environment were available for 165 subjects (see Table 1. for descriptives).

Table 1. Population descriptives

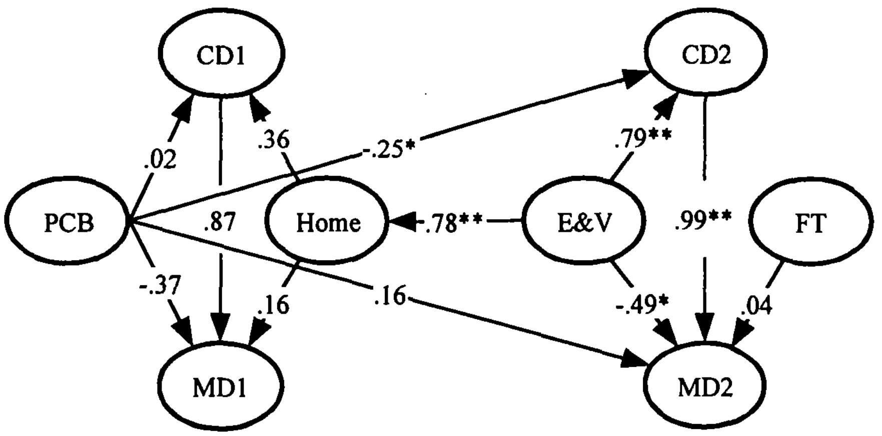
	N (%) / Mean $\pm$ sd / Median (range)
ΣPCB	2.04 (0.59-7.35)
Parental Education	
Low	28 (17%)
Medium	49 (30%)
High	88 (53%)
Parental Verbal IQ	121.62 $\pm$ 16.06
Home18	40.32 $\pm$ 2.77
Home42	39.24 $\pm$ 3.60
Home84	48.01 $\pm$ 3.18
Feeding type: number of breast-fed children	83 (50%)

Table 2. shows the results of the model generation approach. Both cognitive and motor development were adequately represented by a general latent variable, representing development from 3 to 84 months of age (CD1, MD1), and a specific latent variable representing development from 18 months to 84 months of age (CD2, MD2). Cognitive development influenced motor development, and not vice versa. The latent variables Education&Verbal IQ, Home environment and feeding type were necessary to be included in the model to obtain a good fit. The relation between feeding type and the cognitive development did not contribute to the model fit. Structural relationships between the latent variable lnΣPCB and cognitive and motor general latent variables (CD1 and MD1) and respective specific latent variables (CD2 and MD2) were included in the model to identify and estimate the effects of prenatal PCB exposure on CD1, MD1, CD2, and MD2. In Figure 1. standardized estimates of relations between the latent variables are presented. Since the final model (3) seems to fit well, conclusions about the relationships between the variables are justified. Effects of Home environment on CD1 and MD1 were marginal (Figure 1.) as was the effect of feeding type on MD2. A negative direct effect of the latent variable Education&Verbal IQ on MD2 was identified, the total effect (directly and indirectly via CD2), however, is significantly positive. No effect of prenatal PCB exposure on MD1, MD2, and CD1 appeared. The effect of prenatal PCB exposure on CD2 was significantly negative. We conclude that cognitive development after 7 months of age in the Dutch cohort is negatively influenced by prenatal PCB exposure.

Table 2. Results of model generating approach

	χ^2	df	p	RMSEA	AGFI
1. (a) general latent variable CD1 and MD1	468.76	37	0.00	0.200	0.59
(b) 1(a) + specific latent variables CD2 (CD 18, 42, 84) + MD2 (MD 18, 42, 84)	340.05	33	0.00	0.184	0.64
2. Interdependency of latent dependent variables					
(a) CD1 → MD1, CD2 → MD2	152.97	29	0.00	0.139	0.76
(b) 2 (a) + error auto and cross covariances of observed CD and MD variables	51.00	22	0.00	0.069	0.89
3. Performance of latent independent variables, final model					
2(b) + lnΣPCB → CD1 MD1 CD2 MD2 + Education&Verb IQ → CD2 MD2 Home + Home → CD1 MD1 + FT → MD2	111.85	92	0.08	0.029	0.90

RMSEA= root-mean square error of approximation; AGFI= adjusted goodness-of-fit index



FT= feeding type

Figure 1. Final structural model with latent variables. The numbers on the paths are standardized path coefficients indicating the relative strength of the influence. E&V= Education&Verbal IQ, FT = feeding type (0=breast-fed, 1=formula-fed); * $p \leq 0.05$; ** $p \leq 0.01$

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