An application of Structural Equation Modeling in the analysis of ordered categorical factors indicating the relationship between mother-child, father-child, and mother-father interactions impacting cognitive development of US children at age five

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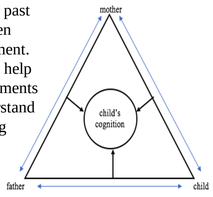
This study was designed to reexamine the influence of parental involvement in a child's life on the child's receptive speech, revealing the moderators' effects along with the direct impact of father-child, mother-child, and father-mother interactions by utilizing the Structural Equation Modeling. An application of SEM allowed us to model unexplained variances and to analyze multiple potential factors of children's vocabulary simultaneously, linking micro and macro-perspectives to avoid misleading interpretations of the factors' effects. While classic estimation methods in SEM assume continuous normally distributed variables, the data collected for this research is mostly ordinal in nature. So, the design of this study specifically accounted for the ordinal variables used. The results revealed that when investigating the 'fathers and mother's degree of involvement predictors of child's vocabulary, the 'status of mother and father cohabitation', 'mother's age', and 'father's attitude towards mother' variables should not be omitted in the model. Otherwise, the results could be misleading, inflating the effect of the father/mother's involvement in a child's activities on a child's speech.

Introduction

This study is designed to address several limitations in past research that aimed to establish the relationship between parental factors and their children's cognitive development. By concentrating on the existing gaps, this project will help not only to reexamine the influence of parent's involvements in child's life but also allow researchers to better understand the interconnection of people in the family by revealing the moderators' effects in the model along with direct impacts of father-child, mother-child, and father-mother relationships.



Parent-child interaction

Notwithstanding the extensive literature on the topic, there is great difficulty in finding an agreed upon definition of the construct of parental involvement. Several studies measure it by the total amount of time spent with the child. This study's design allowed us to differentiate parent-child interaction time and measure it by separating the time spent with the child based on the different activities (playing inside the house, hours playing outside, reading to the child, etc.).

Mother-father interaction.

A measure of the quality of the romantic relationship between mother and father could help to control for a response bias (when due to the parental conflict in the family, the reported hours are higher than they are in reality).
The relationship between mother and father (e.g., bad attitude of the father towards the relationship with the mother) can negatively impact the quality of mother-child interaction, moderating the child's cognitive development outcome.
A factor of mother-father relationship could contribute to the model not only as a moderator but also by directly impacting the cognitive development of the child since the child could be stressed in case of the poor parental relationship.

The central research question of this study is to **(1)** investigate how different degrees of parental, romantic relationship, and paternal involvement in the child's life impact a child's cognitive development. This study will also explore not only the direct and indirect impact of these factors on the analyzed outcome but also **(2)** the interrelationship between such factors.

Methods

The current research utilized the data collected by the Fragile Families and Child Wellbeing Study in the United States. The sample used consisted of 560 families of five-year-old children in which the biological mother was present.

Measures:

Continuous Variables:

- PPVT: a standardized score of the Peabody Picture Vocabulary Test to assess the verbal intelligence (receptive vocabulary) of the child.
- Fage: Father's age
- Mage: Mother's age

Ordered Categorical Variables:

- Fattitude/Mattitude: father's/Mother's attitude towards mother/father, which was assessed by several questions regarding the current relationship with answers from 1= Strongly Disagree, to 5 = Strongly Agree.
- MFCohab: the status of mother and father cohabitation at child's year 5, reported by mother, from 1 = Mothers married to the focal child's father; to 4 = Mothers who didn't live with the respective babies' fathers due to separation, divorce or death
- FInv/MInv: father's/Mother's degree of involvement in child's life, which was assessed by several questions estimating the frequency of the different parent/child activities with answers from 1 = 1/week to 7 = 7/week

Procedure:

We choose the lavaan R package (version 0.5) to perform the SEM analysis since this package was able to deal with binary and ordinal endogenous/exogenous variables, automatically switching to the WLSMV estimator:

- Most variables used in this study are categorical, hence non-normal, with the values not equally distant from each other. As a result, the application of the ML estimator may lead to a biased results.
- In contrast to robust ML, when estimating parameters of the model with ordinal variables, lavaan automatically applied the diagonally weighted least squares estimator (DWLS), which was less biased.
- According to the previous research on the analysis of binary and ordinal variables, the WLSMV estimator proved to be more efficient for large sample sizes resulting in the least parameter estimate and standard error bias (Bandalos, 2014).

Results

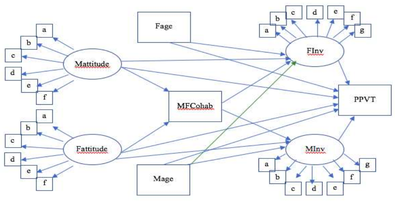
Before the data analysis, all **ordinal exogenous** variables were coded (1,2,3,…) and treated as any other (numeric) covariates, while all **ordinal endogenous** variables were declared as 'ordered' using the <ordered> R function. Next, a CFA model was fitted to investigate the following latent variables: FInv, MInv, Mattitude, Fattitude.

- All items for all four variables were significant, with significant correlations/estimates (>.4). In addition, all fit indices indicated a good fit:

GFI	AGFI	RMR	SRMR	RMSEA	TLI	IFI	CFI
0.99	0.984	0.049	0.051	0.031	0.991	0.991	0.991

- **Due to the ordered categorical nature of the variables, the Chi-Square statistic was disregarded.**

Next, the following hypothesis model 1 was analyzed:



All fit indices indicated an adequate model fit, indicating the model's acceptability:

GFI	AGFI	RMR	SRMR	RMSEA	TLI	IFI	CFI
0.968	0.953	0.169	0.059	0.04	0.983	0.982	0.982

However, the following regressed variables were not significant:
Finv predictors: Mage (p =.278), Fage (p = .864), MFCohb (p = .688)
Minv predictors: MFCohab (p = .323), Mage (p = .994)
PPVT predictors: Mattitude (p = .712), Minv (p = .173), Finv (p = .980)

To improve the model fit, the modification indices were computed, and necessary adjustments were made (addition of the appropriate predictors, removal of the insignificant ones). Next, the resulting model was investigated along with modification indices. These steps were repeated until the final Model 6 was achieved:

MFCohab ~ Mattitude + Fattitude + Mage
FInv ~ Mattitude + Mage
MInv ~ Mattitude + Fattitude
PPVT ~ MFCohab + Fattitude + Mage + MInv + Finv

All fit indices indicated a adequate model fit, suggesting the model's acceptability:

GFI	AGFI	RMR	SRMR	RMSEA	TLI	IFI	CFI
0.976	0.963	0.168	0.052	0.033	0.988	0.989	0.989

The resulting model indicated that all predictors were statistically significant at the alpha level of .05, with an exception of MInv and FInv predicting PPVT. The insignificance of MInv and FInv contradicted the past research, claiming a direct effect of MInv and an indirect effect of FInv on PPVT score.

To reinvestigate this paradox, the following Model 7 was fitted, with Fattitude, Mattitude, Mage, and MFCohab removed:

MInv ~ a*FInv
PPVT ~ b*MInv + FInv
Ind := a*b

This resulted in the significant prediction of PPVT by MInv and MInv by FInv at the alpha level of .05. The indirect effect of FInv on PPVT was not significant at the alpha level of .05, but it was significant at the alpha level .10. It is important to note here that all fit indices indicated a good fit.

➢ **The contradicting results of model 7 and model 6 indicated that, by using a study design without considering the interrelationship between mother and father, researchers can misleadingly exaggerate parental involvement in a child's cognitive development**

Conclusion

The significance of certain effects indicated a possible **gap** in past research, highlighting the importance of including such previously ignored variables as MFCohab, Fattitude and Mage.

- When analyzing the '*fathers and mother's degree of involvement in a child's life'* predictors of PPVT score, MFCohab, Mage, Mattitude variables **should** be included in the model to control the relationship. Otherwise, the results could be misleading, inflating the effect of the *father/mother's involvement* on PPVT.
- The research revealed the following variables indirectly affect the PPVT:
  - Fattitude, Mattitude, Mage impact PPVT via the mediator variable MFCohab.

However, there are some limitations in the study that are important to acknowledge.

- As the next step, the addition of SES to the model could explain the significance of '*the status of mother and father cohabitation'*, since it is possible that single mothers have lower income, compared to full families. Thus, better financial situation of such full families could positively affect the PPVT score.
- While SES is a potential moderator of the '*the status of mother and father cohabitation'* – PPVT effect, it is not likely that SES will significantly influence *'father's attitude towards mother'*. Although, it is still possible, that poor financial situation can produce a stressful atmosphere in the family, indirectly impacting PPVT scores through the problematic relationship between mother and father, resulting a bad attitude of the father towards mother.
- Additionally, although SEM could be potentially highly correlated with the mother's level of education, the inclusion of '*mother's education'* variable into the future investigation could be beneficial, additionally allowing to control the significance of the variables in the model.

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