The Relationship Between Family Factors and Children's Executive Function: A Series of Meta-Analyses

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Abstract

To examine the predictive roles of the Family Investment Model and the Family Stress Model regarding the influence of family factors on children' s executive function, this study employed a three-level meta-analysis technique to analyze 154 studies (comprising 612 effect sizes). The results revealed that: (1) The relationships between family cognitive stimulation (r = 0.146), parenting styles (r_{positive} = 0.169; r_{negative} = -0.128) and children's executive function were more robust than the relationship between parental psychological distress (r = -0.102) and children' s executive function. (2) Compared to questionnaire and video-based methods, family cognitive stimulation measured via home visits yielded larger effect sizes in relation to children' s executive function. (3) When indirect measures were used to assess children' s executive function, the effect sizes for the relationships between parental psychological distress, positive parenting styles, and negative parenting styles with children' s executive function were significantly higher than those obtained using direct measures. (4) Family cognitive stimulation, parental psychological distress, and parenting styles were all significantly correlated with both cool and hot executive functions; however, the type of executive function (cool vs. hot) did not significantly moderate the relationships between these family factors and children's executive function. (5) Variables such as age did not show significant moderating effects on the relationships between the aforementioned family factors and children' s executive function. The findings of this study help clarify the relative roles of family cognitive stimulation, parenting styles, and parental psychological distress in the development of children' s executive function, providing a basis for integrating the Family Investment Model and the Family Stress Model, while also offering a reference for family-based interventions for children' s executive function.

Full Text

The Relationship Between Family Factors and Children' s Executive Function: A Systematic Meta-Analysis

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Abstract

Executive function (EF) refers to the high-level cognitive processes by which individuals consciously control their thoughts and actions to achieve specific goals. It primarily includes inhibitory control, working memory, and cognitive flexibility. As a core component of individual cognitive development, executive function is influenced by various environmental factors, with the family environment being the most direct and fundamental. This study employs a series of meta-analyses to systematically integrate and analyze the relationship between family factors (including socioeconomic status, parenting styles, and parent-child relationships) and children' s executive function development.

To investigate the predictive roles of the Family Investment Model (FIM) and the Family Stress Model (FSM) regarding the influence of family factors on children' s executive function, this study utilizes three-level meta-analysis techniques. The results indicated that home cognitive stimulation ($r = 0.146$) and parenting style ($r = 0.169$) were more closely associated with children' s executive function than parental psychological distress ($r = 0.102$). Compared to questionnaire and video-based methods, home-visit measurements of home cognitive stimulation yielded larger effect sizes in relation to children' s executive function. Furthermore, when indirect measures were used to assess children' s executive function, the effect sizes for the relationships between parental psychological distress, positive parenting style, and negative parenting style with executive function were larger than those obtained using direct measurement methods. While home cognitive stimulation, parental psychological distress, and parenting styles were all significantly correlated with both cool and hot executive functions, the type of executive function (cool vs. hot) did not significantly moderate the relationship between these family factors and children' s executive function.

Variables such as age did not show significant moderating effects on the relationship between the aforementioned family factors and children' s executive function. The results of this study help clarify the relative roles of home cognitive stimulation, parenting styles, and parental psychological distress in the development of children' s executive function. These findings provide an empirical basis for integrating the Family Investment Model and the Family Stress Model, while also offering a reference for family-based interventions aimed at improving children' s executive function.

Keywords: Home cognitive stimulation; Parental psychological distress; Par-

enting style; Executive function; Three-level meta-analysis

1 Introduction

Executive function (EF) is generally defined as a set of high-level cognitive processes that support goal-directed behavior, with inhibitory control, working memory, and cognitive flexibility considered its core components [?, ?, ?, ?]. Based on the degree of emotional and motivational involvement, executive function is often categorized into "cool" and "hot" executive functions [?, ?]. Cool executive function primarily refers to cognitive control processes that operate in emotionally neutral or low-arousal contexts, including attention, flexibility, and planning. In contrast, hot executive function refers to regulatory abilities in motivational contexts involving rewards, delays, or emotional conflict, often measured by tasks such as delayed gratification [?, ?]. This classification is widely adopted in executive function research and helps distinguish the functional characteristics of executive function across different contexts.

The family environment is considered a critical factor in the development of children' s executive function, particularly regarding home cognitive stimulation, parenting styles, and parental psychological distress [?, ?]. However, whether parental psychological distress or home cognitive stimulation plays a more significant role in the development of children' s executive function remains an urgent question to be answered.

On one hand, home cognitive stimulation is regarded as one of the vital factors influencing the development of children' s executive function [?, ?]. [?] utilized home visit observations to measure home cognitive stimulation in infants and found that family socioeconomic status (SES) influences children' s executive function through home cognitive stimulation. Home cognitive stimulation encompasses home learning materials, parental scaffolding, and parental linguistic input [?, ?, ?]. According to the Family Investment Model, parental investment in children—especially investment in cognitive stimulation—can significantly promote children' s cognitive development [?, ?]. When parents create a rich environment through verbal interactions, materials, and the organization of activities, it facilitates the improvement of children' s executive function [?, ?].

On the other hand, parental psychological distress and parenting styles are also recognized as significant factors. [?] investigated home cognitive stimulation through telephone interviews and found that in families with lower socioeconomic status, parental influence reached children' s executive function directly through maternal psychological distress and indirectly through parenting styles; however, home cognitive stimulation failed to significantly impact children' s executive function. This conclusion is inconsistent with the findings of [?]. Nevertheless, previous research has also found that maternal depressive symptoms during the preschool years are uniquely associated with poorer executive function in early childhood [?, ?]. According to the Family Stress Model, parental

psychological distress not only directly affects parents' own emotions and behaviors but may also indirectly undermine children' s executive function through negative parenting styles and negative emotional expression [**?**, **?**, **?**].

These two models are not mutually exclusive; rather, they describe the resource support dimension and the stress-risk dimension of the family environment, respectively. They can be effectively integrated into a more comprehensive framework to provide a more complete description of how family factors shape child development [**?**, **?**]. Resolving the relative strength of these associations helps determine the relative importance of various family factors in explaining the development of executive function. This provides evidence for integrating the Family Investment Model and the Family Stress Model and offers a basis for identifying priority targets for family interventions.

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2 Methods

This study follows the requirements of the PRISMA statement for literature retrieval, quality assessment, and publication bias testing to ensure the systematic nature and reproducibility of the meta-analysis [**?**].

2.1 Literature Search and Selection

This study conducted a comprehensive literature search across several databases, including Scopus, ScienceDirect, Wiley, PubMed, and the China National Knowledge Infrastructure (CNKI). Search terms included keywords such as "cognitive stimulation," "home environment," "parental psychological distress," "parenting style," and "executive function" (including sub-components like working memory and inhibitory control).

The final inclusion for quantitative synthesis consisted of: - Home cognitive stimulation: $n = 56$ studies, 171 effect sizes. - Parental psychological distress: $n = 34$ studies, 164 effect sizes. - Positive parenting: $n = 39$ studies, 201 effect sizes. - Negative parenting: $n = 25$ studies, 76 effect sizes.

2.2 Literature Coding and Quality Assessment

Each included research paper was independently coded based on: year of data collection, type of family factor (e.g., scaffolding, language input, depression, anxiety, coercion), measurement methods (e.g., home visits, questionnaires, observations), and child executive function components (working memory, inhibitory control, cognitive flexibility, etc.). Methodological quality was assessed using the "Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies" [**?**].

2.3 Effect Size Calculation and Model Selection

The correlation coefficient (r) was selected as the effect size metric. All coefficients were converted into Fisher' s z scores for calculation [**?**]. To account for the dependency of multiple effect sizes reported within the same study, this research employed a three-level random-effects model. This partitions variance into sampling error (Level 1), within-study variance (Level 2), and between-study variance (Level 3) [**?**, **?**].

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3 Results

3.1 Home Cognitive Stimulation and Executive Function

The three-level meta-analysis revealed a significant positive correlation between home cognitive stimulation and children' s executive function ($r = 0.146, p < 0.001$). Heterogeneity tests ($Q = 1017.38, p < 0.001$) indicated significant variance, with low intra-study heterogeneity ($I^2 = 15.57\%$) and high inter-study heterogeneity ($I^2 = 80.50\%$).

Moderator analysis showed that the measurement method of home cognitive stimulation was significant: effect sizes from home visits ($r = 0.23$) were significantly higher than those from questionnaires ($r = 0.11$). No significant publication bias was detected (Egger-MLMA: $p = 0.07$; Fail-safe $N = 136,740$).

3.2 Parental Psychological Distress and Executive Function

A significant negative correlation was found between parental psychological distress and children' s executive function ($r = -0.10, p < 0.001$). Heterogeneity was significant ($Q = 1332.94, p < 0.001$), with high inter-study variance ($I^2 = 81.44\%$). Moderator analysis revealed that the executive function measurement method was significant ($Q_b = 9.721, p < 0.01$): correlations using rating scales ($r = 0.148$) were significantly higher than those from direct performance-based measures ($r = 0.075$).

3.3 Parenting Styles and Executive Function

Positive Parenting: A significant positive correlation was found ($r = 0.17, p < 0.001$). Heterogeneity was significant across both Level 2 ($I^2 = 50.63\%$) and Level 3 ($I^2 = 34.61\%$). The moderating effect of EF measurement components was significant: composite EF indices yielded higher effect sizes than single-component measurements.

Negative Parenting: A significant negative correlation was found ($r = -0.18, p < 0.001$). The measurement method of executive function exerted a significant moderating effect ($Q = 6.64, p = 0.012$), with questionnaire-based measures ($r = 0.23$) showing higher correlations than direct behavioral measures.

4 Discussion

4.1 Relative Strength of Family Factors

This study finds that home cognitive stimulation, parenting styles, and parental psychological distress are all significantly associated with children' s executive function. Notably, the effect sizes for home cognitive stimulation and parenting styles were larger than those for parental psychological distress. These findings provide empirical evidence for integrating the Family Investment Model and the Family Stress Model, suggesting that cognitive stimulation and parenting styles serve as more proximal mechanisms affecting EF development [**?**, **?**].

4.2 The Role of Measurement Methods

The method used to measure home cognitive stimulation significantly moderated the results. Home visits, which allow for direct observation of the environment and parent-child interaction, yielded higher effect sizes than self-report questionnaires. This suggests that home visits possess higher ecological validity and reduce social desirability bias. Similarly, indirect measures of EF (parent/teacher reports) generally showed stronger correlations with family factors than direct behavioral tasks, likely because informants observe the child across multiple contexts, though they may also introduce subjective bias.

4.3 Developmental Stability and Integrated Assessment

The study did not find that child age significantly moderated the relationships, suggesting that the influence of family factors on EF may possess cross-stage stability rather than being limited to a "critical period" in preschool. Furthermore, the use of composite EF indices yielded larger effect sizes than single-component measures (e.g., just working memory). This supports the view that EF operates as a holistic construct during childhood and that positive parenting exerts a generalized promotional effect on overall cognitive regulation.

5 Conclusion

1. Home cognitive stimulation and parenting styles are more strongly associated with children' s executive function than parental psychological distress.
2. Measurement methods significantly moderate these relationships: home visits for cognitive stimulation and indirect reports for executive function yield larger effect sizes.
3. Family factors are significantly associated with both "cool" and "hot" executive functions, with no significant difference in effect size between the two types.

Figure 1

Figure 1: Figure 1

Figure 5

Figure 2: Figure 5

4. These findings support the integration of the Family Investment Model and the Family Stress Model in explaining the environmental foundations of cognitive development.

Figures

Figure 7

Figure 3: Figure 7