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EMPIRICAL RESEARCH

Household Income and Early Adolescents' Executive Function: The Different Roles of Perceived Discrimination and Shift-and-Persist

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Abstract

Household income predicts early adolescents' cognitive development. However, the mechanism underlying this association and protective factors are unclear. This study assessed one-year longitudinal data to examine whether perceived discrimination mediated the association between household income and executive function and the moderating role of shift-and-persist. 344 early adolescents in rural China were included in the study (mean = 10.88 years, $SD = 1.32$ years, girls: 51.74%). The latent variable model revealed that household income predicted early adolescents' cognitive flexibility and working memory in the subsequent year through perceived discrimination. Shift-and-persist moderated the negative effects of perceived discrimination on cognitive flexibility: perceived discrimination impeded cognitive flexibility only among early adolescents with low shift-and-persist. The findings highlight perceived discrimination in the relation between household income and early adolescents' executive function and underscore the protective role of shift-and-persist.

Keywords Executive function · Household income · Perceived discrimination · Shift-and-persist · Early adolescents

Introduction

Low family socioeconomic status (SES) hinders children and early adolescents' executive function development (Lawson & Farah, 2017). Numerous studies have focused on the mechanism of family SES influencing executive function, while the role of different or unfair treatment perceived due to poverty, namely, perceived poverty discrimination remains unclear (Major et al., 2002). Compared with Chinese urban early adolescents, those in rural areas are less likely to access medical and educational resources (Li, 2022; Li et al., 2017), resulting in inequality and discrimination (Bradley & Corwyn, 2002). Perceived poverty discrimination may lead to a stronger negative effect than that of poverty itself (Li et al., 2011), reflecting in poor academic performance (Guerra et al., 2019), procrastination (Chao et al., 2012) and other problems that impede development. Understanding the mechanism of perceived discrimination and the underlying protective factors is important for developing intervention on early adolescents' cognitive development. Early adolescents' shift-and-persist reflects their secondary coping strategies in adverse environments and can protect their growth in adversity, helping reduce the "wear and tear" (Chen et al., 2011). This study aimed to examine the effects of household income on early adolescents' executive function through perceived poverty discrimination with one-year longitudinal data and explored the protectively moderating role of shift-and-persist.

Household Income and Early Adolescents' Executive Function

Executive function is coordinated by activities in the prefrontal lobe, including a series of top-down basic cognitive processes of goal-directed behavior (Best & Miller, 2010), mainly including cognitive flexibility, inhibition control and working memory (Lehto et al., 2011). Executive function is of great significance to early adolescents' development and is closely related to their emotional regulation (Mohammed et al., 2022), early learning ability (Ropovik, 2014) and academic achievement (Giordano et al., 2021). Early adolescents' executive

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function is essential to their lifelong achievement, health, wealth and quality of life (Diamond, 2013).

According to the family stress (Iruka et al., 2012) and family investment (Bradley & Corwyn, 2002) models, families with high SES have higher household incomes and more sufficient capital to provide early adolescents with material conducive to their cognitive development. However, families with low SES may adopt negative parenting behaviors that hinder development in early adolescence (Conger & Donnellan, 2007). Early adolescents' family SES positively affects their executive function development (Ming et al., 2021). Compared with youth from high-SES families, those from low-SES families may develop worse executive functioning ability during adolescence (Stumper et al., 2020).

Household income is one of the important indicators reflecting adolescents' family SES (Bradley & Corwyn, 2002), and has been indicated to play a stronger role in the development of early adolescents in rural locations who experienced absolute poverty during childhood (Mistry et al., 2004). A previous study revealed strong correspondence in Chinese rural parents' jobs and education: nearly 90% have an education level below junior high school and jobs related to manual work (Li et al., 2019), leading to minimal SES variability. Meta-analysis results have shown that the relation between SES and executive function became minimal when including studies with little SES variance among the samples (Lawson et al., 2017). Therefore, this study mainly focused on household income instead of family SES and aimed to examine whether household income predicts executive function among Chinese early adolescents.

The Potential Mediating Effect of Perceived Discrimination

Perceived discrimination refers to the different or unfair treatment one perceives due to belonging to a certain group (Major et al., 2002). Economically disadvantaged early adolescents have long experienced disadvantaged situations and more discrimination due to their low SES and lack of resources (Flores et al., 2021). Poor Chinese children also perceived more discrimination than nonpoor children (Li et al., 2011). The identity of the low SES group resulted in more discrimination related to poverty stigma and negative stereotypes (Su et al., 2015), which can negatively affect cognitive development in early adolescence. According to stereotype threat theory (Steele & Aronson, 1995), when individuals face negative stereotypes, they experience stereotype threat; that is, their performance in certain tasks will deteriorate due to the worry of being negatively evaluated in line with the stereotype (Ellemers, 2018). For early adolescents from disadvantaged economic backgrounds, discrimination related to poverty corresponds to negative stereotypes, such as lower cognitive abilities and academic performance (Shutts et al., 2016; Woods et al., 2005), leading to stereotype threat. Stereotype threat causes a physiological stress response in early adolescents, impairing prefrontal processing and triggering the active monitoring of negative stereotypes; thus, self-regulation to suppress negative emotions consumes executive resources used in cognitive or social tasks (Schmader et al., 2008), leading to worse executive function performance. In addition, a previous study found that the effect of perceived discrimination on executive function varied across components. Recent racial discrimination was negatively correlated with young people's cognitive flexibility and working memory but was not significantly correlated with inhibition control (Keating et al., 2022). However, there is a need to investigate the applicability of existing findings to early adolescents.

Most children have developed awareness of discrimination by early adolescence, and adolescents perceive discrimination relatively frequently within multiple contexts (Brown & Bigler, 2005; Wong et al., 2003). Therefore, early adolescence may be a sensitive time for perceptions of discrimination. The inquiry into whether perceived discrimination serves as the psychological mechanism that underlies the impact of household income on various indicators of executive function may help clarify the effect of perceived discrimination on early adolescents.

Potential Moderating Effect of Shift-and-Persist

Shift-and-persist refers to the psychological strategies of coping with stressors by replanning and maintaining optimistic thoughts about the future (Chen & Miller, 2012), including "shift" and "persist" dimensions. "Shift" emphasizes the strategies to accept stressors in daily life and adjust to the environment, while "persist" reflects early adolescents' ability to resist the negative effects of adverse situations by maintaining hope for the future (Chen et al., 2015).

Although there is a lack of research on the protective effects of shift-and-persist on cognitive development, previous studies focused on the moderating effects of shift-and-persist on disadvantaged children and adolescents' health may support the hypothesis. For example, Christophe et al. (2022) demonstrated that shift-and-persist promoted better sleep and reduced anxiety symptoms in the context of discrimination. Shift-and-persist could also decrease low-grade chronic inflammation (Chen et al., 2015), cardiovascular disease risk (Chen et al., 2013) and overweight (Kallem et al., 2013) among adolescents with low SES. In addition, according to the shift-and-persist model (Chen et al., 2012), early adolescents with high shift-and-persist can find "role models" in adversity, which can help them trust others, better regulate their emotions and focus on future development, ultimately leading to adaptation to stress and adversity. Therefore, these studies suggest that shift-and-persist may act as a protective variable, decreasing the negative

effects of poverty and perceived discrimination on early adolescents' executive function.

Current Study

Previous studies have examined the relation between SES and executive function, while little is known from the perspective of different or unfair treatment related to poverty. This study fills the gap by investigating adolescents' perceived poverty discrimination and the underlying protective role of shift-and-persist. The current study hypothesized that household income can significantly positively predict early adolescents' executive function (Hypothesis 1), and perceived discrimination mediates the association between household income and early adolescents' executive function (Hypothesis 2). Additionally, shift-and-persist can be a protective factor for executive function, whereby early adolescents with a high level of shift-and-persist demonstrate a weaker link among household income, perceived discrimination and executive function than those with a low level of shift-and-persist (Hypothesis 3).

Methods

Participants

Monte Carlo power analysis (Wang & Rhemtulla, 2021) indicated that with a statistical power of 0.80 and an α of 0.05, at least 336 participants are required to detect small correlations ($\beta = -0.15$) between perceived discrimination and household income or executive function. Researchers reached out to a local school in an impoverished county in Hebei province[1], China, to obtain the samples. A total of 352 early adolescents aged 8 to 13 were recruited, as their executive functions were still under development (Diamond, 2013), and could be fostered with appropriate circumstances or intervention (Kamijo et al., 2011). Finally, 7 with unfinished questionnaires or cognitive tasks and one with ambiguous information were removed, leaving a total of 344 participants (mean = 10.88 years, $SD = 1.32$ years; 178 girls, 163 boys, and 3 with no reported gender).

A total of 76.74% of the early adolescents' families were either poor or minimal-assurance households registered in the state system. On the whole, these participants' families still had low SES. The SES information and household type details are presented in the Appendix (see Table 2).[2]

Measurement

Monthly household income

Monthly household income was reported by participants' parents through one item: "What is your current monthly household income (for all family members, including bonuses, rent, etc.)" (Xu et al., 2009). The response to this item was combined with the actual situation of the local economy, and the participants' monthly household income was divided into seven levels: (1) below 500 CNY, (2) 500–1000 CNY, (3) 1000–3000 CNY, (4) 3000–6000 CNY, (5) 6000–10,000 CNY, (6) 10,000 CNY–30,000 CNY, and (7) above 30,000 CNY.

Perceived discrimination

Perceived discrimination was measured by the subscale of the family background dimension in the Educational Discrimination Scale (Cai, 2012). The subscale comprises seven items that mainly focus on early adolescents' perceived discrimination related to their family background, such as "Teachers prefer students from families with high SES". Items were accompanied by a 5-point response scale (1 = strongly disagree, 2 = slightly disagree, 3 = not sure, 4 = slightly agree, 5 = strongly agree), with higher average scores representing higher perceived discrimination. The scale has shown good reliability and validity in a previous study on Chinese early adolescents (Cui et al., 2022). In the current study, Cronbach's α was.88.

Shift-and-persist

A shift-and-persist scale (Chen et al., 2015) was used to assess participants' "shift" and "persist". "Shift" and "persist" were assessed with four items using a 4-point scale (1 = not at all, 2 = a little, 3 = some, 4 = a lot). Shift reflected adolescents' secondary coping and reappraisal strategies, such as "I think about what I can learn from the situation". Persist was related to adolescents' life goals, optimism and future orientation, such as "I feel my life has sense of purpose." Items were averaged, with higher scores

[1] The county to conduct the experiment was a Chinese original impoverished county. Since China eliminated absolute poverty in 2020, the county was no longer an impoverished county registered in the state system in 2021 when the second measurement was taken. However, the county was still in a state of relative poverty. According to the National Bureau of Statistics of China (2021), the personal per capita disposable income was 35,128 CNY in 2021, while the per capita disposable income of residents in the county was only 19,614 CNY, approximately only 56% of the national level.

[2] The current study investigated early adolescents living in an original impoverished county in China. Although some of the families were neither poor nor minimal-assurance households registered in the state system, these adolescents' families still experienced relative poverty, as the information in the state system represented only a state of absolute poverty, but not relative poverty. For more details, see Table 2 in the Appendix.

representing early adolescents' higher shift-and-persist. The scale has been well used and demonstrates good statistical characteristics (Mello et al., 2019). In the current study, Cronbach's α for the shift-and-persist scale was 0.75.

Executive function

Executive function was measured by the National Institutes of Health Toolbox (NIH toolbox), assessing early adolescents' cognitive flexibility, inhibition control and working memory. The NIH toolbox is a standardized method to assess early adolescents' cognitive ability and is easy to implement using an iPad (Badaly et al., 2020; Hodes et al., 2013). The NIH toolbox records participants' response time and accuracy and provides age-corrected scores for their executive function. The NIH toolbox has been widely used in research on Chinese early adolescents' cognitive development (Ren et al., 2023).

Cognitive flexibility The Dimensional Change Card Sort Test (DCCS) was used to assess participants' cognitive flexibility. Adolescents were shown two pictures that differed from a target picture in two dimensions (color or shape) and were asked to choose the picture matching the required dimension. Adolescents' accuracy and response time were recorded to assess their cognitive flexibility (adjusted for age).

Inhibition control The Flanker Inhibition Control and Attention Test was used to assess participants' inhibition control, requiring adolescents to pay attention to target stimuli while ignoring irrelevant stimuli. In each trial, adolescents were presented with five arrows in a row on the screen and were asked to choose the arrow that pointed in the same direction as the most central arrow (regardless of whether the other arrows pointed in the same direction as the central arrow). The adolescents' response time and accuracy (adjusted for age) reflected their inhibition control level.

Working memory Participants' working memory was measured by the List Sorting Working Memory Test. The test was divided into two parts, in which adolescents were shown a series of pictures on a screen (animals in the first part; food and animals in the second part) and given corresponding voice prompts. After the picture presentation, adolescents were asked to recall and name the animals in the pictures they had seen in the first part in order from small to large; subsequently, they were asked to name the food and animals shown in the second part in a specific order. During each part, the number of pictures increased as participants named them correctly until they provided two incorrect answers successively or successfully named seven objects in a row in a trial. Trained experimenters used keyboards to record whether participants named the pictures correctly. The number of named pictures and the difficulty of each reflected the adolescents' working memory.

Adolescents' family economic status

The participants' parents also reported variables reflecting early adolescents' family economic status, including the parents' education level, job and household type. Parents' education levels were coded on a 9-point scale, from 1 (uneducated) to 9 (postgraduate) (Ge, 2020). Parents' jobs were coded on a 5-point scale, from 1 (casual, unemployed, or unskilled/agricultural workers) to 5 (senior professional managers, professional/technical personnel, or professional supervisors) (Shi & Shen, 2007). Household type referred to whether adolescents' families were formally registered as impoverished (annual income below the national poverty line of CNY 2300) or obtained the minimal living allowance.

Details regarding adolescents' family economic status are presented in Table 2 in the Appendix.

Procedure

The Institutional Review Board of the authors' affiliated institution, the local educational departments, and the principals of each school approved the investigation protocols (No. 202004010035). Meanwhile, informed consent was obtained from the adolescents and their parents before the formal experiment. At the first measurement (T1: November 2020), all adolescents reported their gender, age, and perceived discrimination experiences by questionnaire. Parents reported their monthly household income, education level, job and household type. Adolescents completed the shift-and-persist scale in the second measurement (T2: November 2021) and completed executive function tasks on the iPad under the guidance of trained researchers. At the end of each measurement, stationery was given to the adolescents as a gift for participating.

Statistical Analysis

First, correlations, descriptive statistics and standardized regression coefficients between variables were obtained in SPSS 26.0. The measurement model for latent variables was evaluated by confirmatory factor analysis (CFA) in Mplus 8.3 (Muthén & Muthén, 2015).

Second, the latent mediation structural model and bootstrap method (MacKinnon et al., 2004) were used to explore the mediating role of perceived discrimination. Comparative index (CFI), Tucker–Lewis Index (TLI) > 0.90 and root-mean-square error of approximation (RMSEA) < 0.08 denoted a good model fit (Browne & Cudeck, 1992; Hu & Bentler, 1999). The chi-square/*df* (χ^2/df) and 95% C.I. were also reported.

Finally, the latent moderated structural equations (LMS) method (Maslowsky et al., 2015) was used to further explore the moderated mediation effect. The logarithmic likelihood ratio tests between Model 0 (without moderation effect) and Model 1 (with moderation effect) were determined: a significant D (-2[(log likelihood for Model 0) - (log likelihood for Model 1)]) indicated a better fit for Model 1. In addition, ΔR^2 between two models indicated the R^2 explained by the interaction. A simple slope test was conducted if the moderating effect of shift-and-persist was significant. Standardized coefficients were all obtained from the Mplus standardized output.

Results

Descriptive Statistics

No significant correlation was found between monthly household income and the three indicators of executive function ($ps > 0.05$). Adolescents' perceived discrimination was negatively related to monthly household income ($r = -0.11$, $p = 0.042$), cognitive flexibility and working memory ($rs = -0.15$, $ps < 0.01$). Shift-and-persist was positively related only to working memory ($r = 0.18$, $p = 0.001$, see Table 1).

Measurement Models

CFA comprised the two latent variables (perceived discrimination and shift-and-persist). The latent perceived discrimination model was indicated by seven items. Shift-and-persist was represented by eight items. The overall model provided an adequate fit to the data ($\chi^2_{(112)} = 177.26$, $p < 0.001$, RMSEA = 0.04, CFI = 0.962, TLI = 0.954). Multigroup CFA (Byrne, 2011) indicated that the measurement model was demonstrated across genders. That is, the scale measured the same underlying constructs in both males and females. Absolute values of the standardized factor loadings ranged from 0.38 to 0.88 and were all significant at $p < 0.001$.

Different Roles of Perceived Discrimination and Shift-and-Persist

Predicting for cognitive flexibility

Monthly household income (T1) cannot directly predict adolescents' cognitive flexibility (T2, $\beta = -0.07$, $SE = 0.05$, $p = 0.227$). However, the latent variable mediation model revealed that perceived discrimination (T1) completely mediated the effect of monthly household income on adolescents' cognitive flexibility ($\chi^2/df = 1.24$, CFI = 0.995, TLI = 0.992, RMSEA = 0.027, 95% C.I. = [0.004, 0.053]). A lower monthly household income increased adolescents' level of perceived discrimination ($\beta = -0.14$, $SE = 0.06$, $p = 0.009$), resulting in a lower level of cognitive flexibility ($\beta = -0.16$, $SE = 0.06$, $p = 0.010$).

The LMS method was used to further explore the moderating effect of shift-and-persist. First, model 0 was constructed, which contained only the main effect of shift-and-persist in the absence of a latent interaction variable (perceived discrimination * shift-and-persist). The results showed that Model 0 fit well with a log likelihood of −7319.52 ($\chi^2/df = 1.49$, CFI = 0.969, TLI = 0.961, RMSEA = 0.038). Model 1 was then constructed, which included the effect of the latent interaction variable, unlike Model 0. The log likelihood of Model 1 was −7316.65. The log likelihood ratio test between Model 1 and Model 0 showed that Model 1 significantly improved the goodness of fit compared with that observed with Model 0 ($D = 5.74$, $\Delta df = 1$, $p = 0.017$). Meanwhile, the interaction between perceived discrimination and shift-and-persist increased the variance interpretation rate, $\Delta R^2 = 0.012$. Shift-and-persist did not significantly predict adolescents' cognitive flexibility ($\beta = 0.02$, $SE = 0.06$, $p = 0.684$); however, the

Table 1 Correlations, means, and standard deviations for study variables

Variables	*n*	1	2	3	4	5	6	7	8
1. Gender	341	–							
2. Age (T1)	344	0.10	–						
3. Monthly household income(T1)	339	−0.02	−0.13*	–					
4. Perceived discrimination(T1)	343	0.20***	0.03	−0.11*	–				
5. Shift-and-persist(T2)	333	0.11*	−0.06	0.08	−0.02	–			
6. Cognitive Flexibility(T2)	344	−0.07	−0.12*	−0.07	−0.15**	0.03	–		
7. Inhibition Control(T2)	343	0.01	−0.08	−0.07	−0.01	0.02	0.47***	–	
8. Working Memory(T2)	343	0.16**	−0.06	−0.02	−0.15**	0.18**	0.17***	0.17***	1
M		–	10.88	2.75	1.67	22.86	100.50	92.22	92.06
SD		–	1.32	1.15	0.83	4.06	14.78	14.77	12.39

Gender (1 = boys, 0 = girls) is a categorical variable. Spearman correlations are reported for the correlation between categorical and continuous variables

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

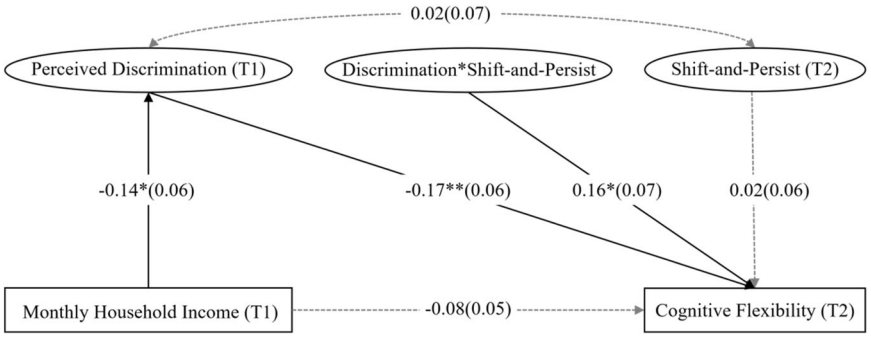

Fig. 1 Standardized coefficients of Model 1 for monthly household income, perceived discrimination, cognitive flexibility and shift-and-persist. The solid lines represent significant paths, while the dotted lines represent insignificant paths. *$p < 0.05$, **$p < 0.01$

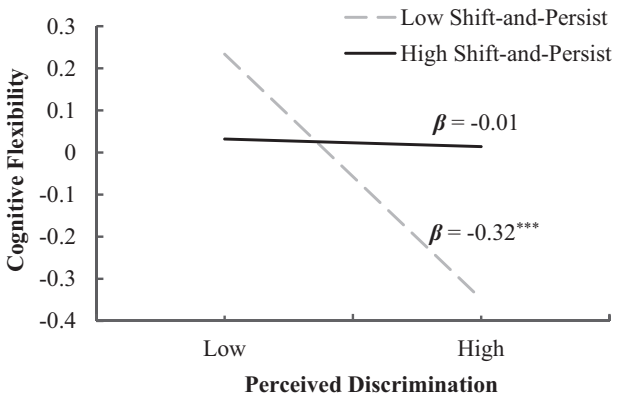

Fig. 2 The moderating effect of shift-and-persist. ***$p < 0.001$

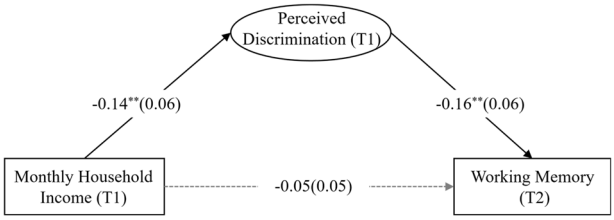

Fig. 3 Standardized coefficients of the model for monthly household income, perceived discrimination, and working memory. The solid lines represent significant paths, while the dotted lines represent insignificant paths. **$p < 0.01$

interaction between adolescents' perceived discrimination and shift-and-persist positively predicted their cognitive flexibility ($\beta = 0.16$, $SE = 0.07$, $p = 0.027$, see Fig. 1).

Finally, a simple slope test was used to further explore the moderation effect of shift-and-persist (see Fig. 2). For adolescents with higher shift-and-persist, there was a weaker association between perceived discrimination and cognitive flexibility ($\beta = -0.01$, $p = 0.901$); nevertheless, for adolescents with lower shift-and-persist, the more discrimination they perceived, the lower their cognitive flexibility was ($\beta = -0.32$, $p < 0.001$).

Predicting for working memory

Similarly, monthly household income (T1) could not significantly predict adolescents' working memory (T2, $\beta = -0.02$, $SE = 0.05$, $p = 0.661$). However, the mediation model indicated that their perceived discrimination completely mediated the effect of monthly household income on working memory ($\chi^2/df = 1.39$, CFI = 0.993, TLI = 0.988, RMSEA = 0.034, 95% C.I. = [0.004, 0.052]). Early adolescents with higher monthly household incomes perceived less discrimination ($\beta = -0.14$, $SE = 0.06$, $p = 0.009$), resulting in better working memory ($\beta = -0.16$, $SE = 0.06$, $p = 0.004$) (see Fig. 3).

Further exploration of the moderation effect of shift-and-persist revealed that the interaction between perceived discrimination and shift-and-persist did not significantly predict early adolescents' working memory ($\beta = 0.07$, $SE = 0.07$, $p = 0.333$), indicating the insignificant moderation effect of shift-and-persist.

Predicting for inhibition control

There was no significant relation between monthly household income (T1) and early adolescents' inhibition control (T2, $\beta = -0.07$, $SE = 0.05$, $p = 0.236$). In addition, the mediation effect of perceived discrimination was not significant (95% C.I. = [−0.014, 0.024]). Moreover, the study explored the moderation effect of shift-and-persist alone, which was demonstrated to be insignificant ($\beta = 0.04$, $SE = 0.06$, $p = 0.567$).

Discussion

The negative effect of economically disadvantage on early adolescents' executive function may even last to adulthood (Evans & Schamberg, 2009). Focusing on the mechanism of the relation can help to better understand early adolescents' cognitive development and prescribe the relevant interventions. The current study extended prior work on investigating the effect of household income on executive function through perceived discrimination and the underlying protective factors. The results revealed perceived discrimination on income disparities as a mediator between monthly household income and early adolescents' cognitive flexibility and working memory.

Additionally, shift-and-persist is a protective factor in the cognitive flexibility of early adolescents with high perceived discrimination.

The mediation effect of perceived discrimination explained how SES, as a distal factor (Hackman et al., 2010), influenced early adolescents' executive function from the perspective of chronic stress, adding to the existing research on the potential proximal factors affecting adolescents' cognitive development, such as parenting styles (Conger & Donnellan, 2007) and language ability (Daneri et al., 2019). According to the reserve capacity model, stressful events triggered by a low-SES environment reduce adolescents' reserve capacity to manage stress, giving rise to vulnerability to negative emotions and cognition (Gallo & Matthews, 2003). The mediating effect of perceived discrimination in the current study provided empirical evidence for the reserve capacity model and stress and coping theory (Lazarus & Folkman, 1984). Perceived discrimination acts as a social stressor, easily triggering adolescents' defense system and keeping them in a state of stress (Gallo & Matthews, 2003), thereby leading to worse social adaptation and cognitive performance (Hood et al., 2017).

The mediation analyses in the current study revealed a mediating effect of perceived discrimination on cognitive flexibility and working memory but not inhibition control among early adolescents. The results were consistent with a study on racial discrimination (Keating et al., 2022). Two reasons might explain these results. First, according to stereotype threat theory, negative stereotypes are potential social threats to early adolescents' development (Schmader et al., 2008). Therefore, adolescents may need to allocate cognitive resources to cope with the threat posed by stereotypes (Lewis et al., 2015), while such allocation may focus adolescents' attention on the stereotypes themselves, hampering the shift of attention (cognitive flexibility) and maintenance of long-term targets (working memory) (Keating et al., 2022). Second, the effect of perceived discrimination on inhibition control may vary with the dimension of inhibition. A meta-analysis revealed that the type of inhibition moderates the effect of stress on inhibition: stress significantly enhances response inhibition (suppressing prepotent responses) while restricting cognitive inhibition (processing information selectively) (Shields et al., 2016b). This may be why the current and related studies did not observe a significant relation between perceived discrimination and inhibition control. Future studies may further divide inhibition control into the two aspects above to clarify the effect of perceived discrimination and monthly household income. To be noted, these consistent results may imply that various kinds of perceived discrimination have the same essence: the perception of different or unfair treatment (Major et al., 2002). Although people who perceive discrimination may belong to different groups, their membership puts them in the minority, leading to reducing resources and increasing stress that stunt their development (Bradley & Corwyn, 2002).

The protective role of shift-and-persist in early adolescents' cognitive flexibility was revealed in the current study. For adolescents with high shift-and-persist, the negative effect of perceived poverty discrimination was mitigated; thus, emphasizing the protective effect of shift-and-persist might help identify resilience-promoting processes in early adolescents' cognitive development. According to the shift-and-persist model, adolescents in adversity with high shift-and-persist are more likely to cope with "tear and wear" by adapting to stress with cognitive reappraisal (shift) while remaining tough and optimistic and finding meaning in the future (persist) (Chen & Miller, 2012). Therefore, shift-and-persist may buffer the adverse impact of perceived discrimination, which can be considered a kind of chronic stress that would harm cognitive flexibility (Shields et al., 2016a, 2016b). Although further research is needed, the current results first expanded the protective effect of shift-and-persist to early adolescents' cognitive development.

However, this study has some limitations. First, the limited sample size in the current study precluded the cross-validation of the results despite sufficient statistical power. In addition, it remains unknown whether the present results can be generalized to a broader population. Further research with more diverse samples will be essential to address this issue. Second, although the current study explained the effect of perceived discrimination from the perspective of stereotype threat and chronic stress, the current study focused on only early adolescents' perceived discrimination related to poverty and did not directly measure their stereotype threats or stress. Future studies should pay close attention to children's stereotype threats related to poverty to further clarify the status of children's cognition on the effect of poverty and discrimination. Physiological indices such as cortisol should be measured in the future. Finally, the current study expanded the protective effect of shift-and-persist to only early adolescents' cognitive development. It remains under exploration whether shift-and-persist has the same positive effect on early adolescents' psychological health.

Conclusions

Despite previous evidence for the association between economically disadvantage and executive function, limited knowledge exists on perceived poverty discrimination as the mechanism. The present study tackled this problem by investigating the longitudinal relation between monthly household income and executive function through early adolescents' perceived discrimination. The results revealed perceived discrimination related to poverty as a mechanism for economically disadvantaged adolescents' worse cognitive flexibility and working memory. In addition, a protective role, shift-and-persist has been found to buffer the negative effect of their

perceived discrimination on cognitive flexibility. The current results emphasized the importance to focus on early adolescents' perceived discrimination related to poverty and shift-and-persist, which can provide information on interventions for economically disadvantaged children and youth.

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Authors' Contributions J.Z. conceived of the study, performed the statistical analysis, participated in the research design, data curation, and interpretation of the data results, and drafted the manuscript; K.M. participated in data curation, and the interpretation of the data results, and commented on the manuscript; Y.D. participated in the interpretation of the data results, and commented on the manuscript; Y.R. participated in the interpretation of the data results, and commented on the manuscript; S.H. acquired the research funding, administrated and supervised the project, participated in the interpretation of the data, reviewed and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

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Data Sharing and Declaration The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Ethical Approval This study was conducted in accordance with the ethical principles for research involving human participants, and approval of the investigation protocols was obtained from the Institutional Review Board of the authors' affiliated institution (No. 202004010035), the local educational departments, and the principals of each school.

Informed Consent Children and their parents gave written informed consent for the investigation.

Appendix

Table 2

Table 2 Descriptive statistics for family economic status

Indicators	Items	Number	Proportion
Household type	poor household	250	72.67%
	minimal assurance household	32	9.30%
	general household (neither)	80	23.26%
Parents' degree of education	uneducated	5	1.45%
	elementary school	58	16.86%
	junior high school	209	60.76%
	technical/vocational high school	16	4.65%
	senior high school	17	4.94%
	technical secondary school	24	6.98%
	college	10	2.91%
	university graduated	4	1.16%
	postgraduate	1	0.29%
Parents' job	casual, unemployed, or unskilled/ agricultural workers	213	61.92%
	manual workers, self-employed workers, or skilled workers and other equivalent workers	93	26.74%
	general management personnel, professional/technical personnel, or clerical staff	21	6.10%
	mid-level managers, professionals and technicians, or assistant professionals	11	3.20%
	senior professional managers, professional/technical personnel, or professional supervisors	3	0.87%
Monthly household income	below 500 CNY	48	13.95%
	500–1000 CNY	88	25.58%
	1000–3000 CNY	136	39.53%
	3000–6000 CNY	46	13.37%
	6000–10,000 CNY	13	3.78%
	10,000–30,000 CNY	5	1.45%
	above 30,000 CNY	3	0.87%

Note. The total proportion of all household types exceeded 100%, as some of the children's families were both poor and minimal assurance household. Parents' education degree or job is the maximum of the father's and mother's. *CNY* China Yuan

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