Does parental autonomy support mediate the relation between parent and infant executive function? A study of mothers and fathers in the Netherlands and China.

Li, W.; Nefs, H.T.; Emmen, R.A.G.; Woudstra, M.J.; Branger, M.C.E.; Wang, L.; ... ; Mesman, J.

Infant Behavior and Development 71 (2023) 101833

Contents lists available at ScienceDirect

Infant Behavior and Development

journal homepage: www.elsevier.com/locate/inbede

Does parental autonomy support mediate the relation between parent and infant executive function? A study of mothers and fathers in the Netherlands and China

Wei Li [a,*], Harold T. Nefs [a], Rosanneke A.G. Emmen [a], Mi-lan J. Woudstra [a], Marjolein C.E. Branger [a], Lamei Wang [b], Lenneke R.A. Alink [a], Judi Mesman [a]

[a] Institute of Education and Child Studies, Leiden University, the Netherlands
[b] School of Psychology, Shenzhen University, China

ARTICLE INFO

Keywords:
Autonomy support
Executive function
Mothers and fathers
Infancy
Cross-country

ABSTRACT

Parenting skills, such as Autonomy Support (AS), have been proposed as a potential mechanism explaining the intergenerational contiguity of Executive Function (EF). However, few studies have focused on mothers *and* fathers among non-Western families. The current study investigated the role of maternal and paternal AS in the relation between parental EF and infant EF at 14 months of age among 123 Dutch and 63 Chinese first-time mothers and fathers and their infants. Multiple-group structural equation models were built for mothers and fathers separately with country as a grouping variable. Results showed that parental AS did not mediate the relation between parent EF and infant EF at 14 months. Mean-level differences were found in parental AS, maternal EF, and infant inhibition across countries, while no country differences were found in the relation between parent EF, AS and infant EF. Our findings suggested that individual differences in early EF may not be stable enough to be reliably predicted from parental factors across the Netherlands and China.

1. Introduction

Executive function (EF) is a higher-order cognitive process that includes goal-directed actions such as inhibition, working memory and cognitive flexibility (e.g., Miyake et al., 2000). Research suggests that EF is transmitted across generations (Cuevas et al., 2014a; Deater-Deckard, 2014; Kao et al., 2018). Besides genetic inheritance, parenting quality has been proposed as a potential mechanism explaining the intergenerational contiguity of EF (e.g., Cuevas, et al., 2014b). An aspect of parenting relevant for EF is parental autonomy support. Autonomy support refers to sensitively assisting children to complete a task based on children's own skills (Grolnick & Ryan, 1989). This parenting skill not only puts high cognitive demands on parents but also most consistently predicts child EF (e.g., Bernier et al., 2010; Hughes & Ensor, 2009). Although there is considerable evidence supporting the relation between parental EF and child EF (e.g., Kao et al., 2018), between parental EF and autonomy support (e.g., Mazursky-horowitz et al., 2019), and between autonomy support and child EF (e.g., Valcan et al., 2018) separately, few have investigated those associations among fathers and non-Western samples. Moreover, as far as we know, only one study (in a Western sample) investigated autonomy support as an explaining mechanism of intergenerational transmission of EF. Results showed that autonomy support mediated the relation between

* Corresponding author.
E-mail address: w.li@fsw.leidenuniv.nl (W. Li).

https://doi.org/10.1016/j.infbeh.2023.101833
Received 31 May 2021; Received in revised form 2 March 2023; Accepted 6 March 2023
Available online 28 March 2023

parental EF and child EF at 3- to 5-years (Distefano et al., 2018). However, little is known about the association between autonomy support and child EF in the first two years of life. To begin to address these critical gaps, the current study investigated the role of maternal and paternal autonomy support in the relation between parental EF and infant EF at 14 months of age in the Netherlands and China.

EF appears early in the first year of life and develops rapidly across infancy and the preschool period. Most research indicates that the maturation of attention lays the foundation for the development of EF (e.g., Baddeley, 2001; Miyake et al., 2000). Previous neuroimaging studies propose that the executive attention network regulates other brain networks (e.g., Posner & Rothbart, 2007) such as networks in the prefrontal cortex that are strongly associated with the development of EF (e.g., Welsh & Pennington, 1988). The development of infant attention starts with the orienting system, which is important for infants to engage with novel stimuli. Later development of the attention system facilitates infants' ability to select and focus on the stimuli, as well as the later ability of shifting between objects (Garon et al., 2008; Hendry et al., 2016). With those emerging systems of attention, infants are able to process information from their surroundings which is necessary for any goal-directed task (Garon et al., 2014). Previous studies have argued that infants in the second year of life are capable of completing EF tasks because in general, they have the ability to hold information (working memory) and to inhibit responses to one rule and then shift to a different rule (conflict inhibition; Diamond, 1985, 1988). An empirical study supported this argument and found that infants at 14 months of age showed high levels of compliance with the EF tasks (Devine et al., 2019). These studies provided evidence for the early emergence of EF and the feasibility of testing EF in the early years, but obviously individual differences exist. Studies among children younger than 2-years-old in Western and non-Western countries also consistently showed that there are no significant correlations among different EF components (e.g., Johansson et al., 2016; Li et al., 2022; Wiebe et al., 2010), which indicates that EF may first emerge as separate component skills that become more integrated in the preschool years.

Previous work indicated that parental EF is associated with child EF (Bridgett et al., 2011; Cuevas et al., 2014a, 2014b; Kao et al., 2018). This link can partially be explained through genetics (e.g., Friedman et al., 2009), but also through parental behaviors (e.g., Cuevas et al., 2014b). A recent meta-analysis of 42 studies on early childhood EF (average age 12.77 months) indicated small but significant associations between responsive-affective (responsiveness, sensitivity, warmth) and cognitive (autonomy support, scaffolding and cognitive stimulation) parental behaviors and better child EF skills, and between negative parental behaviors (control, intrusiveness, detachment) and poorer child EF (Valcan et al., 2018).

Autonomy support (AS) has been demonstrated as a potential parenting mechanism underlining the link between parental EF and child EF (e.g., Distefano et al., 2018). Based on Vygotskian theories, caregivers structure tasks in order to facilitate children to become independent (Vygotsky, 1978). Wood (1980) named this process scaffolding, one of the central components of autonomy support, referring to the strategies that parents use to support or assist their children to independently and skillfully carry out tasks that are beyond children's current level of ability. AS also consists of other aspects such as taking children's perspective and giving them the opportunity to play an active role in the completion of a task (Grolnick & Ryan, 1989). This process puts a high demand on parental cognitive capacities as parents need to plan and monitor the whole task according to the child's progress, inhibit their own controlling behaviors and allow the child to make its own choices at their own pace (e.g., John et al., 2018). In a study of 5- to 10-year-old children and their mothers, maternal EF predicted scaffolding in a sample of mothers and children with (parent-reported) attention deficit/-hyperactive disorder (ADHD) as well as in a sample of mothers and typically developing children (Mazursky-horowitz et al., 2019). Similar results were reported in a recent study involving mothers and their 3.5–4.5-year-old children (John et al., 2018). Besides the high cognitive demands on parents, autonomy support is also the most consistent parenting predictor of child EF in the preschool period (Bernier et al., 2010; Distefano et al., 2018; Eason & Ramani, 2017; Hammond et al., 2012; Hughes & Devine, 2019; Matte-Gagné & Bernier, 2011). Therefore, it is likely that AS mediates the association between parent EF and child EF.

As far as we know, studies investigating parental EF, autonomy support or scaffolding, and child EF together in one study have all focused on the preschool period (Distefano et al., 2018; Korucu et al., 2020; Obradović et al., 2019). For example, AS mediated the association between parent EF and child EF, which was confirmed by Distefano et al. (2018) in a sample of 3- to 5-year-olds and their mothers. Another study also found that parental performance in EF-specific activities mediates the relation between parental EF and child EF (average 51 months of age; Korucu et al., 2020). Yet relatively little research has investigated early EF development during the first two years of life. It is feasible to study infant EF as different studies have shown that infants can complete the tasks at a high level (e.g., Diamond, 1985, 1988). As infants are heavily dependent on caregivers for supporting the development of their behavioral self-regulation, and both parental cognitive abilities and parenting are related to the development of infant EF (Bridgett et al., 2015; Hendry et al., 2016), it is vital to test the role of parental precursors in early EF development. Our first aim therefore was to replicate and extend existing work by examining the relation between parental EF, AS, and infant EF at 14 months in both a Western sample and a non-Western sample. The first hypothesis was that better parental EF would be associated with higher levels of AS, which in turn would predict better infant EF, and that parental EF would also be directly associated with infant EF.

To date, studies testing associations between parental EF, AS, and child EF have largely been restricted to Western samples. The country context can have an impact on parenting and child development and on the associations between parenting and child behavior (e.g., Cheah et al., 2015; Li et al., (2019)). As far as we know, only one study investigated maternal scaffolding, maternal cognitive abilities and child EFs in a non-Western context, namely in rural Pakistan (Obradović et al., 2019). Results showed that maternal verbal intelligence partially mediated the concurrent relation between maternal scaffolding and child EFs at 48 months. China is of particular interest in the study of EF. It has been shown that Chinese children outperform their counterparts in Western countries on EF skills during preschool and middle childhood periods (Sabbagh et al., 2006; Schmitt et al., 2018; Wang et al., 2016). Whether these differences appear in early childhood, and whether parental factors such as parent EF and parenting contribute to these differences remains unknown. Studies that only focused on Chinese samples found that parental AS accounted for unique variance in child EF

among preschoolers (Cheng et al., 2018; Sun & Tang, 2019) which is in line with results from Western studies (e.g., Hughes & Devine, 2019). Other studies compared the associations between parental EF, AS, and child EF in Chinese and Western samples (Cheung et al., 2016) indicated that controlling and autonomy supportive parenting reported by children (average age 13 years) and mothers similarly predicted children's academic achievement (related to EF skills) in the U.S. and China. Little evidence was found for country differences in the mean levels of parenting skills in this study. Ellefson et al. (2017) also found that although young adolescents in Hong Kong outperformed their counterparts in the UK on all EF tasks, the correlation between parent EF and child EF was found in both countries with Hong Kong dyads showing larger effect size than the UK counterparts. In other words, the association between AS and academic achievement, and between parental EF and child EF appeared to be culturally invariant. Cross-country comparisons on those associations could also shed light on the generalization of Western theories on child EF development to non-Western samples. The second aim of the current study was to investigate the associations between parental EF, AS, and infant EF in the Netherlands and China. The second hypothesis was that the mediation model would be similar across countries.

In addition to the gap of limited non-Western studies on correlates of EF, studies on fathers and infants are scarce in both Western and non-Western countries. Theoretical and empirical evidence has demonstrated that fathers play an important role in child development (Mcloyd, 1990). For example, different from mothers who are more emotionally available for the child (e.g., Volling et al., 2002), father-child interactions are characterized by more physical and challenging behaviors (e.g., Malmberg et al., 2016). These behaviors may stimulate different parts of cognitive development compared to behaviors more typically shown by mothers. Consistent with studies on mothers, studies on fathers have supported the positive associations between paternal EF and adolescents' EF (Jester et al., 2009), between paternal EF and parenting behaviors (Mokrova et al., 2010), and between paternal AS and child EF (Meuwissen & Carlson, 2015). However, none of these studies considered paternal EF, AS and child EF together. A review conducted by Li and Lamb (2015) indicated that Chinese fathers have become involved more in childrearing in recent years, and have an independent impact on young children's cognitive development and academic achievement. Thus, investigating both Chinese mothers and fathers is important to fully understand parental gender roles in the development of child EF. To address this gap, the third aim of the current study was to investigate the role of fathers in infant cognitive development in the Netherlands and China. We aimed to explore the potential similarities and differences between mothers and fathers regarding the correlates of infant EF.

1.1. The current study

Although many studies have found support for the associations between parental EF, AS, and child EF separately, few studies have focused on: a) non-Western samples, b) fathers, and c) EF in infancy. We aimed to test the mediating role of AS in the relation between parental EF and infant EF at 14 months of age. We also tested whether the mediation model is similar among fathers and mothers across the Netherlands and China. Our first aim was to examine the relation between parental EF, AS, and infant EF at 14 months. We hypothesized was that better parental EF would be associated with higher levels of AS, which in turn would predict better infant EF, and that parental EF would also be directly associated with infant EF. Our second aim was to investigate the associations between parental EF, AS, and infant EF in the Netherlands and China. We hypothesized that the mediation model would be similar across countries. The third aim of the current study was to investigate the role of fathers in infant cognitive development in the Netherlands and China. We aimed to explore the potential similarities and differences between mothers and fathers regarding the correlates of infant EF.

2. Method

2.1. Participants

One hundred and twenty-three Dutch and 63 Chinese first-time mothers and fathers and their infants at age of 14 months (NL: 45% boys, China: 51% boys) participated in the current study. Dutch families were recruited at pregnancy fairs, yoga classes and midwifery practices throughout the whole country while Chinese families were recruited at a regional maternity and child hospital, through colleagues' friends and online groups in Shenzhen, China. Only families with healthy, full-term and singleton infants were eligible to participate. All participating parents were first-time parents who were 21 years or older during pregnancy, native Dutch or Chinese

Table 1
Demographic Information of Mothers, Fathers and Infants in the Netherlands and China.

	The Netherlands			China		
	M	*SD*	*Range*	*M*	*SD*	*Range*
Child age (months)	14.19	0.52	9.47 – 16.07	14.83	1.16	11.92 – 18.48
Maternal age (years)	30	3.82	21–42	30	2.94	22–37
Paternal age (years)	32	4.35	24–46	31	3.86	24–45
Education						
	High	Moderate	Low	High	Moderate	Low
Mothers (%)	72	12	16	70	30	0
Fathers (%)	58	16	26	76	21	3

Note. High education = a bachelor degree or higher; moderate education = a postsecondary or short-cycle tertiary education; Low education = an upper secondary degree or less

(Mandarin or Cantonese) speakers, and had no history of any mental illness or substance misuse (self-reported). Participants were part of a cross-cultural and longitudinal study which was conducted in the UK, the US, the Netherlands and China. Dutch mothers and fathers were visited at home when the mothers were 36 weeks pregnant and when the infant was 4, 14 and 24 months of age. The mother-infant and father-infant dyads in China were visited at 4 and 14 months of infant age. Only data at 14 months were used for this study. Dutch families were visited from March 2016 to November 2016 and Chinese families were visited from June 2017 to December 2017. The data of the EF at 14 months was also part of a previous report that presented analyses of infant attention at 4 months and sensitive caregiving of both mothers and fathers at 4 and 14 months as predictors of EF at 14 months in the Netherlands and China (Li et al., 2022).

Demographic information is summarized in Table 1 in the Netherlands and China. Dutch fathers were on average older than were Chinese fathers, $t(175) = -2.63$, $p = .009$, $d = .43$. There were no differences in maternal age, $t(180) = -1.56$, $p = .121$. Most of the parents were highly educated. Dutch fathers, on average, had lower educational levels than Chinese fathers, $\chi^2(6) = 28.53$, $p < .001$, $\varphi = .33$, and the same was true for mothers, $\chi^2(7) = 21.51$, $p = .003$, $\varphi = .23$.

2.2. Procedure

Mothers and fathers were visited separately, and each home visit lasted between 90 and 120 min. The order of home visits was counterbalanced. All fathers and mothers signed an informed consent form for their own participation as well as their infants' participation. Infants at 14 months were tested with an age-appropriate battery of EF tasks in a fixed order: inhibition, working memory and cognitive flexibility. After all infant tasks, parents and infants played an inset jigsaw puzzle task together for 4 min. All the toys required for the tasks were provided by the research team to ensure the same toys among all families. Toys offered for the mother and the father were different but comparable in the same family. Parents completed computer EF tasks (i.e., Hearts and Flowers, Tower of Hanoi) at the end of the visit. Brief reports about background information (e.g., education, SES) were completed by parents before or after each home visit. The study was approved by the Ethics Committee Leiden University in the Netherlands and Shenzhen University in China (for the part of the study in China).

2.3. Measures

Parental Executive Function. Parents completed a short battery of tasks on the computer using Eprime to present the stimuli and record responses. Parents were asked to respond as quickly as they could while maintaining accuracy.

2.3.1. Shifting and inhibitory control

Parents completed the Hearts and Flowers task ((Davidson et al., 2006; Diamond et al., 2007). In the first set of 15 congruent trials, parents were shown a picture of a heart for 750 ms. If the heart appeared on the right, the parent pressed the 'right' key. If the heart appeared on the left, the parent pressed the 'left' key. In the second set of 15 trials (incongruent trials), parents were shown a picture of a flower for 750 ms. Parents were instructed to press the 'left' key if the flower appeared on the right, and to press the 'right' key if it appeared on the left. The final phase consisted of 15 mixed trials (hearts and flowers) in which parents were instructed to respond according to the rules established in the first two trials. Reaction time and accuracy were recoded for all three sets. Responses faster than 200 ms were excluded as they indicated a failure to wait for the upcoming stimulus or to release the button following the previous trial (Davidson et al., 2006). Efficiency scores were calculated for the mixed block (the mean accuracy divided by median reaction time for correct responses).

2.3.2. Planning, inhibition and working memory

Parents completed the Tower of Hanoi task (Shallice, 1982). They were first shown a completed configuration consisting of two pegs and three disks of different sizes. Parents were invited to rearrange the configuration with limited moves. Only one disk could be moved each time and a bigger disk could not be placed on top of a smaller one. The test ended when parents accomplished the reconfiguration. Scores were calculated by total errors.

To create a composite parent EF score, we calculated as the Z score of the efficiency score of Hearts and Flowers minus the Z score of the errors of the Tower of Hanoi (e.g., Deater-Deckard et al., 2012). Higher scores indicated better EF skills.

Parental Autonomy Support. Parents were asked to play an inset jigsaw puzzle task together with the infant for 4 min. Observed autonomy support was coded using the Autonomy Support Coding Manual (Whipple et al., 2011). Parental behaviors were rated on four scales according to whether parents: (a) provided appropriate help; (b) gave instructions, encouragements and praises; (c) took their infants' perspective and keep them on the task; and (d) respected their infants as an active player. Each of the scales was assessed for autonomy support, controlling and laissez-faire on a 1–5 scale (1-not autonomy supportive or not controlling or not laissez-faire, 5-very autonomy supportive or very controlling or very laissez-faire). Only autonomy support scores were used in the current study, and an average score was calculated as the final score based on the four scales. All videos were coded by two independent Chinese and six Dutch coders. Chinese videos were coded by Chinese coders, and Dutch videos were coded by Dutch coders. A quarter of the videos were double coded for reliability. Both Dutch and Chinese coders first coded an international reliability set including 30 videos (the US: 10, the UK: 10, NL: 10). Dutch videos were with English subtitles. Intercoder reliabilities (interclass correlation, single rater, absolute agreement) between Dutch and Chinese coders was.76 on average on autonomy support for all dyads (range:.70–.88). Intercoder reliabilities between pairs of six Dutch coders was.81 on average (range:.71–.86.). Two Chinese coders also coded a reliability set including 10 Chinese videos. Intercoder reliabilities between the Chinese coders was.86.

Infant Executive Function. Infants completed a short battery of tasks (lasting approximately 8–10 min) developed by Devine et al. (2019). Infants were seated on a parent's lap or a booster chair in front of a table. Parents were instructed to remain silent and not to influence infants' behaviors through either gesture or vocalization. Breaks were provided after each task and infants were praised at the end of each task to maintain their interests in the task. The descriptions of each task have been described in the previous reports (Devine et al., 2019; Li et al., 2022) and that we repeated the information in the current manuscript. 60 videos of each task from the larger and multi-national investigation have been double coded to check the reliability of the task. The task of Inhibition demonstrated high levels of inter-rater agreement ICC = .99, $p < .001$. The tasks of Working Memory and Cognitive Flexibility also demonstrated high inter-rater reliability for each trial, Kappa = 1.00 for both tasks. A factor score was obtained for three EF tasks.

2.3.3. Inhibition

Infants completed a Prohibition task (Friedman et al., 2011). After the home visitor's instruction "Don't touch", infants were required to resist touching a shiny glitter wand up to 30 s. Scores were collapsed into two categories (i.e., 0 = touches before 30 s, 1 = does not touch before 30 s).

2.3.4. Working memory

Infants completed a Multi-Location Search task also called Three Boxes task (Miller & Marcovitch, 2015). Infants were asked to find three toy cars (i.e., red, yellow and blue plastic cars) hidden in three toy garages with colored doors (i.e., red, yellow and blue) with a short delay of 5 s between each search. The procedure was discontinued if the child failed to find a toy for three consecutive trials or when the child retrieved all three cars. Three scores were created: total number of searches to find the (1) second and (2) third cars (i.e., 0 = did not find; 1 = 3 searches; 2 = 2 searches; 3 = 1 search) and (3) the strategy used to search for the cars with higher scores referring to a more efficient search strategy (i.e., 0 = starts in the middle, 1 = starts at either edge and then selects middle, then middle again, 2 = starts at either edge and then selects middle but then repeats a search, 3 = starts at edge, then middle, then other edge).

2.3.5. Cognitive flexibility

Infants completed a Ball Run task (Hughes & Ensor, 2005). In the learning phase, infants were instructed to place a colored ball (i.e., green) into one of the two colored holes (i.e., green). The other hole (i.e., red) was closed by using one metal bracket. A switch speaker with nursery song was activated if infants placed the ball into the correct hole. If infants scored four or more trials out of six correctly (NL: $N = 48$, China: $N = 25$), they processed to the reversal phase. Infants were instructed to place a different colored ball (i.e., red) into another colored hole (i.e., red). Scoring took place offline. Infants received one point for each correct trial. Those who did not pass the learning phase (scored less than four) received a score of 0 on all trials of the reversal phase.

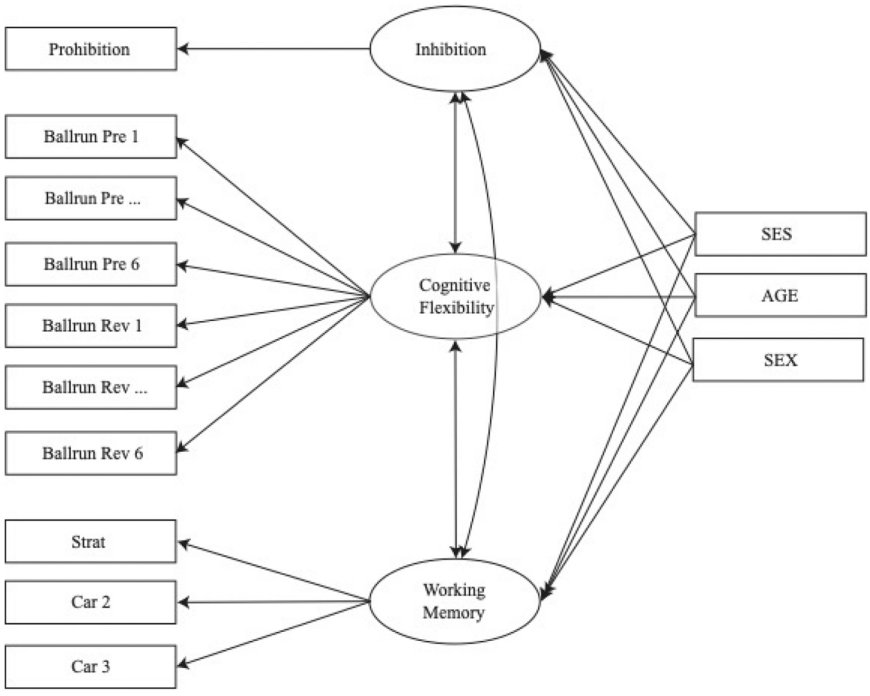

Fig. 1. *The Structural Equation Modeling for the Fitted Model in the First Stage*, *Note*: Ballrun Pre1 = Ballrun trial 1 in the pre-learning phase. Ballrun Rev 1 = Ballrun trial 1 in the reversal phase. Strat = strategy. SES=Social Economic Status.

2.3.6. Socio-economic status (control variable)

Parents completed the Ladder of Subjective Social Status (Singh-Manoux et al., 2003) which indicates their rating on a 10-rung ladder with the top referring to the best income, employment, education and the bottom with worst. The educational level of parents was correlated with the ladder scores in both mothers, $r = .23$, and fathers, $r = .20$. Parental socioeconomic status (SES) was calculated by aggregating the mean standardized score across the four indicators, i.e., maternal and paternal education level, maternal and paternal ladder score, $\alpha = .64$ (Devine et al., 2019).

2.4. Statistical analysis

The primary analyses were conducted in two stages in R-studio (R studio team, 2015) using the Lavaan package (Rosseel, 2012) for structural equation modeling. First, a structural equation model was fitted to the data in order to obtain three measures for infant EF, namely "prohibition", "three boxes" and "ball run". Family socioeconomic status (SES), child age in months, and child gender (0 = Girl, 1 = Boy) were included as covariates. The fitted model is shown in Fig. 1. A nearly identical model was proposed by Devine et al., 2019. This model provided a good fit to the data, $\chi^2(102) = 228.77$, CFI = 1.00, TLI = 1.00, RMSEA = .00. Factor scores for the three infant EFs were then obtained from the model and used in the later analyses.

In the second stage of the analyses, multigroup structural equation models (SEM) were built to examine the relations between parental EF, parental AS and the three measures for infant EF at 14 months. Country was used as a grouping variable. These models are illustrated in Fig. 2.

Throughout this paper, structural model fit was assessed with chi-square, the comparative fit index (CFI) and the tucker-Lewis index (TLI) and the root mean square error of approximation (RMSEA). CFI and TLI values of.95 or greater and.90 or greater were considered evidence of good and adequate fit, respectively (McDonald & Marsh, 1990). RMSEA values of.05 or less and.08 or less were considered evidence of good and adequate fit, respectively (Browne & Cudeck, 1992). Significant indirect effects were taken as evidence of mediation which were tested using the multiple bootstrap procedure described by Fritz et al., 2012 within an SEM framework. We then tested whether the relaxation of the constraints led to a significant improvement in goodness of fit for the unconstrained versus the (partly) constrained models. The results of the model comparisons are described in the next two sections for the maternal and paternal data, and are also illustrated in Fig. 3. We used Maximum Likelihood and NLMINB as estimator and bootstrapping to estimate standard errors. The data for mothers and fathers were analyzed separately.

3. Results

3.1. Descriptive statistics

Descriptive statistics for parental and infant EF variables in the Netherlands and China are summarized in Table 2. We tested the main variables for differences in mean using t-tests and a chi-square test for dependency for dichotomous variables. It was found that mean maternal EF was significantly higher in the Netherlands than in China ($t(173) = -2.78$, $p = 0.006$, $d = .44$). In addition,

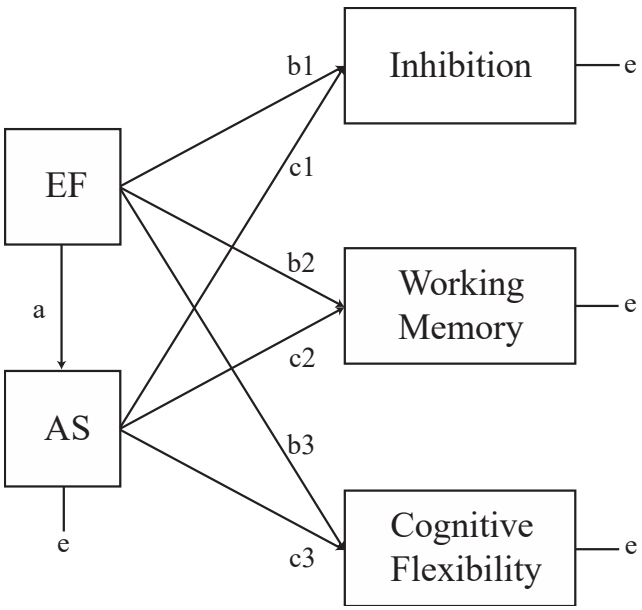

Fig. 2. *The Structural Equation Modeling for the Fitted Model in the Second Stage, Note.* EF = Parental Executive Function. AS = Parental Autonomy Support.

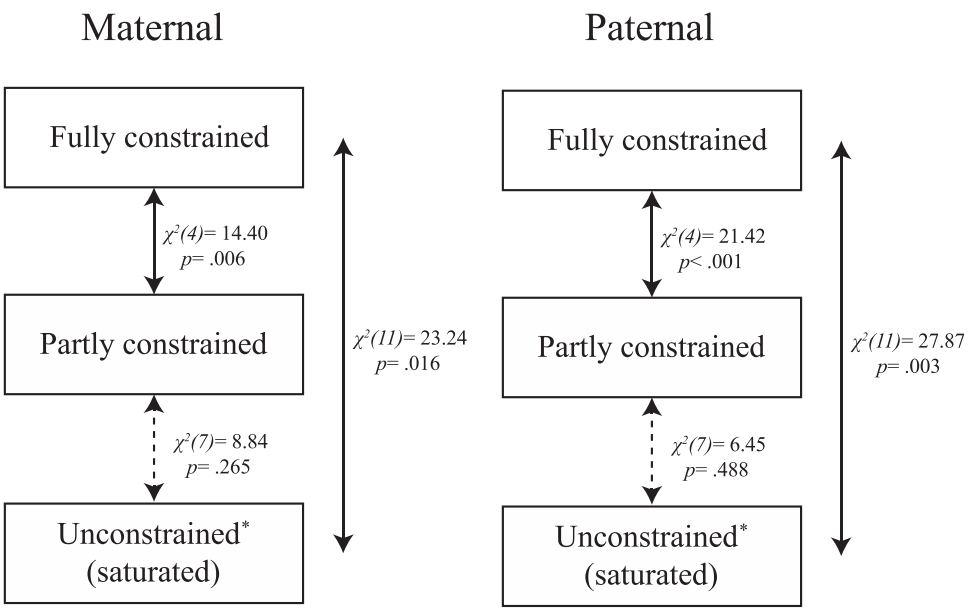

Fig. 3. *Likelihood Ratio Tests for the Comparison Between Three Models (Fully Constrained Model, Partly Constrained Model and Unconstrained Model) for Maternal and Paternal Models*, *Note*: * the completely unconstrained model was equal to a saturated model.

Table 2
Descriptive Statistics for Parental Measures and Infant Executive Function Tasks.

	Pooled					The Netherlands					China				
	Mean	*SD*	*Min*	*Max*	*N*	*Mean*	*SD*	*Min*	*Max*	*N*	*Mean*	*SD*	*Min*	*Max*	*N*
Country	0.66	0.47	0.00	1.00	186	1.00	0.00	1.00	1.00	123	0.00	0.00	0.00	0.00	63
MEF	0.00	0.77	-2.82	1.35	177	0.10[a]	0.70	-2.22	1.27	123	-0.23[a]	0.85	-2.82	1.35	54
PEF	0.02	0.74	-2.29	1.82	166	0.06	0.73	-2.21	1.82	115	-0.06	0.78	-2.29	1.43	51
MAS	3.54	0.69	1.50	5.00	184	3.69[a]	0.66	1.50	5.00	123	3.23	0.65	2.00	4.67	61
PAS	3.17	0.71	1.50	5.00	173	3.37[a]	0.60	1.50	5.00	116	2.77	0.73	1.50	4.67	57
WM	-1.00	0.48	-1.44	0.50	119	-0.98	0.50	-1.44	0.50	77	-1.01	0.45	-1.43	0.44	42
CF	0.34	0.32	-0.01	0.93	119	0.31	0.32	-0.01	0.93	77	0.39	0.32	-0.01	0.87	42
IB	-0.39	0.44	-0.65	0.35	119	-0.33[a]	0.47	-0.65	0.35	77	-0.51	0.35	-0.65	0.35	42

Note. MEF = Maternal Executive Function. PEF = Paternal Executive Function. AS = Autonomy Support. WM = Working Memory. CF = Cognitive Flexibility. IB = Inhibition. [a] indicates significant differences between the Netherlands and China. * $p \leq .05$, * * $p \leq .01$

autonomy support was higher in the Netherlands than in China for both mothers, $t(182) = -4.45$, $p < .001$, $d = .68$, and fathers, $t(171) = -5.67$, $p < .001$, $d = .90$. Of the three child executive functions, only the performance on the prohibition task was significantly different between the two countries ($\chi^2(1) = 10.31$, $p = .001$, $\varphi = .25$) with Dutch infants displaying higher levels of inhibition than Chinese counterparts. Other differences were not significant.

3.2. Relations between parental EF, parental AS and infant EF

Multiple-group structural equation models with Country as the grouping variable were built to describe the mothers' and fathers' data separately. The basic model is shown in Fig. 2. Three models were built sequentially for the mother and the fathers respectively. 1) In the fully constrained model both regressions and intercepts were forced to be equal for both countries. 2) In the second model, i.e. the partly constrained model, the constraint on the intercepts was relaxed and were hence estimated separately for the two countries. 3) In the third model, i.e. the fully unconstrained model, there were no constraints imposed on the paths.

It should be noted that looking at the correlation matrix in Table 3, there were no strong significant relations between child and parent variables. Prospects for a good fitting model were therefore obviously limited.

3.2.1. Maternal data

All maternal models are summarized in Table 4. The maternal constrained model did not yield a particularly good fit to the data. We tested whether the model fit was significantly worse than for a saturated model, which it was; $\chi^2(11) = 23.24$, $p = .016$; CFI = 0.00, TLI = 7.233, RMSEA = .140; LL = −290.859, AIC = 631.719, BIC = 700.124, sample size adjusted BIC = 621.107, indicating that the constrained model was not able to reproduce the data well. In this model there was only one marginally significant path between AS

Table 3
Correlations for Pooled Data and for Dutch and Chinese samples.

	MEF	PEF	MAS	PAS	WM	BR	IB	Country	Gender	Age	SES
Pooled data											
MEF	.	.11	.23**	.18*	.09	-.03	-.07	.26**	-.09	-.18*	.02
PEF		.	.13	.08	.10	-.09	.09	.10	-.10	.11	-.21**
MAS			.	.41**	.06	-.01	.12	.39**	.09	-.01	.07
PAS				.	.07	.15	.08	.48**	-.03	-.04	-.03
WM					.	.06	.06	.04	-.05	.09*	.07
CF						.	-.02	-.15	-.08	.11	-.11
IB							.	.27*	.12	-.12	.08
Country								.	.09	-.47**	-.02
Gender									.	-.10	.12
Age										.	.05
SES											.
	MEF	PEF	MAS	PAS	WM	BR	IB	Country	Gender	Age	SES
MEF	.	.08	.10	.03	.01	.03	-.13	x	-.21*	.07	.08
PEF		.	.07	.01	.07	-.04	.16	x	-.21*	.09	.03
MAS			.	.19*	.05	.03	.15	x	.15	.00	.13
PAS				.	.01	.22*	-.09	x	-.02	.01	.25**
WM					.	.11	-.07	x	-.16	-.12	.04
CF						.	.02	x	-.17	.01	.22*
IB							.	x	.09	.07	-.00
Gender									.	.06	.01
Age										.	.04
SES											.
	MEF	PEF	MAS	PAS	WM	BR	IB	Country	Gender	Age	SES
MEF	.	.24	.31*	.17	.07	-.17	.22	x	-.03	-.26	.12
PEF		.	.19	.13	.23	-.33*	-.03	x	.09	.09	-.03
MAS			.	.56*	.08	-.07	.05	x	-.10	.19	.42**
PAS				.	.17	-.08	.18	x	-.12	.14	.42**
WM					.	-.12	-.03	x	.12	-.06	-.05
CF						.	-.03	x	-.14	.11	.07
IB							.	x	.15	-.09	.02
Gender									.	-.10	.02
Age										.	.19
SES											.

Netherlands
China
Note. * $p \leq .05$, ** $p \leq .01$. Correlations between ordinal variables are polychoric. Correlations between categorical variables are tetrachoric. MEF = Maternal Executive Function. PEF = Paternal Executive Function. MAS = Maternal Autonomy Support. PAS = Paternal Autonomy Support. IB = Inhibition. WM = Working memory. CF = Cognitive flexibility. SES = Socioeconomic status. Country: China = 0, the Netherlands = 1. Child gender: girl = 0, boy = 1.

and maternal EF ($p = .045$). However, since the model did not provide a good fit to the data, further analyses to compute direct and indirect paths are not reported here.

Next, in the maternal partly constrained model, we relaxed the constraint that the four intercepts in the model should be equal in the two countries but kept the constraints that the regression parameters were to be equal in the two countries. This yielded a model that was not significantly different from a saturated model, $\chi^2(7) = 8.84$, $p = 0.265$, LL = −283.659, RMSEA = 0.068, AIC = 625.318, BIC = 704.668, sample-size adjusted BIC = 613.009, suggesting that the model fit of this model was reasonable. When inspecting the model paths in detail (see Table 4), we did not find significant regression paths in either the Netherlands or China. The only significant parameters were found in the intercepts, indicating that there were some differences in the mean level between the two countries.

To examine whether the indirect and direct effects were similar across countries, the second constraint, i.e. the regression parameters had to be equal for both countries, was further relaxed. The fits of the two models were then compared to determine if the paths were significantly different between the two countries.

The maternal completely unconstrained model was a just-identified model with just as many free parameters as covariances to fit, and it therefore had a perfect fit to the data; LL= −279.242, AIC= 630.483, BIC = 728.987, sample-size adjusted Bayesian BIC = 615.203. The path estimates of this model are shown in Table 4. Further inspection of the results revealed that there was a single significant path namely between AS and inhibition in the Dutch sample ($p = .027$). This path did not reach significance (at 5% level) in the Chinese group. Because there were no further significant paths, significance tests for indirect paths are thus not further pursued here.

We then conducted likelihood ratio tests to see whether the relaxation of the constrains led to a significant improvement in goodness of fit for the unconstrained versus the (partly) constrained models (see Fig. 3).

(1) Fully constrained model versus partly constrained model, $\chi^2(4) = 14.40$, $p = .006$, indicating that the relaxation of the constraint on the intercepts led to a significant improvement in model fit compared to the fully constrained model.

(2) Unconstrained model versus fully constrained model. Because the completely unconstrained model was just-identified (i.e. it

Table 4
Estimated Parameters for the Maternal Models.

		Constrained			NL Constrained (Regressions Only)			China Constrained (Regressions Only)			NL Unconstrained			China Unconstrained		
Label	*Lhs*	*Est*	*SE*	*Std.all*	*Est*	*SE*	*Std.all*	*Est*	*SE*	*Std.all*	*Est*	*SE*	*Std.all*	*Est*	*SE*	*Std.all*
Regressions																
a	MAS	0.18 *	0.09	0.19	0.16	0.08	0.17	0.16	0.08	0.21	0.11	0.12	0.12	0.23	0.14	0.30
b1	IB	0.09	0.06	0.13	0.05	0.06	0.08	0.05	0.06	0.10	0.08	0.08	0.12	-0.01	0.10	-0.02
c1	IB	-0.01	0.06	-0.02	-0.02	0.06	-0.03	-0.02	0.06	-0.05	-0.15 *	0.07	-0.24	0.10	0.07	0.26
b2	WM	0.02	0.07	0.02	0.02	0.07	0.03	0.02	0.07	0.02	0.03	0.08	0.04	0.00	0.14	0.00
c2	WM	0.05	0.07	0.07	0.05	0.07	0.07	0.05	0.07	0.08	0.05	0.08	0.08	0.06	0.12	0.11
b3	CF	-0.02	0.05	-0.05	-0.01	0.05	-0.02	-0.01	0.05	-0.02	0.01	0.06	0.02	-0.05	0.08	-0.11
c3	CF	-0.01	0.04	-0.03	-0.01	0.04	-0.02	-0.01	0.04	-0.02	0.02	0.05	0.04	-0.04	0.07	-0.10
Intercepts																
a	MAS	3.53 * *	0.07	4.88	3.65	0.08	5.14	3.33 * *	0.10	5.32	3.66 * *	0.08	5.20	3.34 * *	0.10	5.24
b1	IB	-0.74 * *	0.21	-1.54	-0.51	0.24	-1.11	-0.72 * *	0.22	-2.27	-0.61 *	0.27	-1.31	-0.50	0.33	-1.60
b2	WM	-1.03 * *	0.25	-2.09	-1.05	0.24	-2.12	-1.04 * *	0.24	-2.23	-1.09 * *	0.29	-2.19	-0.97 *	0.49	-2.07
b3	CF	0.43 *	0.17	1.34	0.36	0.18	1.11	0.44 * *	0.17	1.46	0.28	0.21	0.87	0.58 *	0.28	1.90
	MEF	0.08	0.00	0.10	0.08	0.00	0.10	-0.14	0.00	-0.17	0.08	0.00	0.10	-0.14	0.00	-0.17

Note. * = $p \leq 0.05$, * * $p \leq .01$. MEF = Maternal Executive Function. MAS = Maternal Autonomy Support. IB = Inhibition. WM = Working memory. CF = Cognitive flexibility. NL = the Netherlands.

was a saturated model), this test is equivalent to the chi-square test when the constrained model was compared to the saturated model ($\chi^2(11) = 23.24$, $p = .016$). This finding implies that the relaxation of the constraint that the regression paths had to be equal in two countries lead to a significantly better fit. Although the improvement in fit was significant, when considering the AIC and BIC criteria we see little improvement since they are very similar for the constrained and unconstrained models and in the case of the BIC criterion. The value for the constrained model was actually higher than for the unconstrained model (AIC: 631.719 vs 630.483 and BIC: 700.124 vs 728.987 for the constrained vs the unconstrained models respectively) indicating that the improvement in model fit did not justify the addition of extra parameters in the model.

(3) Unconstrained model versus partly constrained model. Also because the fully unconstrained model was just-identified, the likelihood ratio test for the comparison between the fully unconstrained model and the partly constrained model equals the test reported earlier for partly constrained vs saturated ($\chi^2(7) = 8.84$, $p = .265$). That is, there was no further significant improvement in model fit due to relaxing the constraint on the regression parameters. The difference in significance in the path between AS and inhibition in the two countries cannot be seen as an indication of a significant difference between the two countries.

Overall, in these data, country affected the intercepts in the model significantly, but the model did not improve further by letting the regression coefficients vary between the two countries which was expected when considering the *t*-tests that were reported at the beginning of the Results section, but not the regression parameters. These results for these three models therefore further imply that we did not find indications in this data that maternal AS mediated the relations between maternal EF and neither of the three infant EFs nor country acted as a moderator on the mediation of AS between maternal EF and child EF.

3.2.2. Paternal data

For the paternal data, we followed the same testing procedure as for the maternal data. Similar to the maternal model, the fit of the fully constrained paternal model was not very good. The partly constrained paternal model was not significantly different from the saturated model. We then compared the unconstrained model versus the (partly) constrained models. Similar to the findings in maternal data, there was no indication in paternal data that AS mediated a relation between parent and any of the three child executive functions although a significant path (cognitive flexibility and AS) was found in the Dutch group ($p = .008$). You can find the detailed results of paternal data in Supplemental Materials.

4. Discussion

The current study investigated the mediating role of parental autonomy support in the relation between parental Executive Function and infant Executive Function at 14 months of age and tested whether these relations differ across the Netherlands and China for fathers and mothers. Our aims were to: 1) examine the relation between parental EF, AS, and infant EF at 14 months; 2) investigate the associations between parental EF, AS, and infant EF in the Netherlands and China; and 3) investigate the role of fathers in infant cognitive development. Our findings showed that: 1) AS did not mediate the relation between parental EF and infant EF, and parental EF was not related to infant EF; 2) there were no country differences in the mediation, but countries differences in two single paths have been found; and 3) there were no indications in either the maternal or the paternal data for mediation. Besides the above results, we also looked at descriptive statistics for parental and infant EF variables in the Netherlands and China. Results showed that: 1) mean maternal EF was significantly higher in the Netherlands than in China; 2) autonomy support was higher in the Netherlands than in China for both mothers and fathers; and 3) Dutch infants showed higher levels of inhibition than Chinese counterparts. We now elaborate our findings in more detail.

4.1. Intergenerational transmission of EF

In contrast to our hypothesis, no intergenerational transmission of EF was found for either mother-infant dyads or father-infant dyads. The young age of infants may be one of the possible explanations for our unexpected finding. Although Deater-Deckard (2014) has proposed an ecological model of intergenerational transmission of EF through socialization process and biological mechanism, the evidence to support this model so far is from children older than 24 months of age (Cueva et al., 2014a, 2014b; Kao et al., 2018). Infants in the current study were 14-month-old. According to the developmental phase of self-regulation (Kopp, 1982), cognitive growth occurs between 9 and 18 months. The frontal lobe that is related to the successful performance on EF tasks develops rapidly during the first two years of life (e.g., Dawson et al., 1992). The literature indeed suggested that the heritability of EF increases with age which means the similarity of EF across generations may be more salient among older children (Mullineaux et al., 2009). The age of 14-month is still an early stage of EF development which may be characteristic of unstable EF abilities. This may explain why we found no relation between parent and infant EF. Another possible explanation for this null finding is the association of EF components differs between infants and adults. Miyake et al. (2000) described an integrative theoretical framework of the opposing theories on the development of EF: "unity and diversity of EF". This theory indicates that EF components are partially independent but still intercorrelated with one another. Some studies indicated that the unity and independence of three EF components (i.e. working memory, inhibition, and cognitive flexibility) may vary in different age groups (Best & Miller, 2010). For example, working memory was found to be related to inhibition, and cognitive flexibility was not related to the other two components among preschoolers (Senn et al., 2004). Another study found that inhibition was independent of working memory and cognitive flexibility, and the latter two components were associated with each other among 7-,11-,15-, and 21-year-olds (Huizinga et al., 2006).

Moreover, the fact that different measurements of parent EF and infant EF were used in the current study may be another reason for the absence of findings showing intergenerational transmission of EF. It is difficult to use the same measurement for parent EF and

infant EF as age-appropriate tasks are required for young children. The two parental EF tasks (Hearts and Flowers; Tower of Hanoi) that were used in the current study are the "classic" EF tasks. The ability of shifting and inhibitory control is required for Hearts and Flowers. Planning, working memory and inhibition have been proposed to be essential to complete Tower of Hanoi (Welsh & Huizinga, 2001). Our parental EF tasks captured the most important EF component of parents which is similar but not exactly the same as infant EF: inhibition, working memory and cognitive flexibility (e.g., Miyake et al., 2000). As previous research has shown that measurements and constructs of parental EF in the study of parental EF and child EF have been inconsistent (Distefano et al., 2018; Korucu et al., 2020; Obradović et al., 2019), future studies are needed to examine the relation between parental EF and child EF using same measurements in different samples.

4.2. Country differences in the mediation

No countries differences were found in the overall mediation, however, our findings showed country differences in two single paths. Among Dutch parent-infant dyads, maternal AS significantly predicted 14-month inhibition while paternal AS significantly predicted 14-month cognitive flexibility. We did not find similar result in China. Although the relations were not significantly different between the two countries, the findings among Dutch parent-infant dyads extended previous studies supporting the positive relation between autonomy supportive-parenting and cognitive abilities in the preschool period to later childhood (e.g., Hughes & Ensor, 2009). However, it is not clear why mothers and fathers contributed to different aspects of child EF. One possible explanation can be the different interactive patterns between mothers and infants and fathers and infants. A recent systematic review of father-child play showed that father-infant interactions are generally characterized by more intensive, high arousal, physical and "rough-and-tumble" play other than pretence or fantasy play in mother-infant interactions (Amodia-Bidakowska et al., 2020). Because of the different interaction patterns of mothers and fathers, infants may respond differently to mothers and fathers, and those gender-specific interactions may stimulate different aspects of self-regulation development.

Note that although the relation between maternal or paternal AS and inhibition or cognitive flexibility (separately) in the Netherlands was significant, the effect size was small. Previous studies that established a strong link between AS and child EF focused on the impact of early AS on later EF (children older than 24 months). This may suggest a delayed effect indicating that the predictive effect of parental AS is more salient on predicting child EF in a later period than in the concurrent time. In addition, children older than 24 months of age can perform more complicated tasks and explore more. Parental involvement in those activities may be more meaningful for EF development. Two Chinese studies supporting the significant relation between maternal scaffolding and child EF investigated child EF in the preschool period (3–5-years old; Cheng et al., 2018; Sun & Tang, 2019), so parental behaviors may contribute to the development of EF among preschoolers.

4.3. Different associations in maternal and paternal data

We only found an association between parental EF and parental AS among Chinese mothers but not among Chinese fathers and Dutch mothers and fathers. The difference in maternal EF between mothers in the Netherlands and China may be a reason for the different associations. There is more variability in the EF data for Chinese mothers compared to Dutch mothers. This difference may contribute to the different relations between maternal EF and maternal AS in the two countries. Future studies are needed to look into the mechanism underlying these differences in EF and its relation to maternal AS. Different assessments that we used for parental EF than others studies may be a reason for other non-significant results.

4.4. Mean-level differences in AS, parental EF and infant EF

Mean-level differences were found in parental AS, maternal EF, and infant inhibition across countries. Dutch parents showed higher levels of AS than Chinese parents. The lower AS scores in China may be partly related to the high value placed on acquiring knowledge and "Guan" which implies "parental care, concern, and involvement are combined with strict control and governance of the child with low democracy" in the Chinese culture (Chao, 1994). Chinese mothers believe that "Guan" represents parents' effort and love which are important for children's achievement (Mori & Liu, 2012). Although not all Chinese parents show this pattern (e.g., Yue et al., 2019), in the current study, it was more common for Chinese parents to show low autonomy supportive behaviors compared to Dutch parents. For example, compared to Dutch parents, Chinese parents were more likely to use instructions or hold infants' hands to finish a task. Such behaviors indicate low autonomy support when infants do not show signals of requiring or wanting help. Dutch mothers performed better on EF tasks compared to Chinese mothers, and Dutch infants showed higher levels of inhibition than Chinese infants. Also, the different working arrangement for mothers in the Netherlands and China may explain the difference in maternal EF across countries. In the Netherlands, most women work part-time after they have children, however, working part-time is generally impossible in China as the working flexibility is limited. Therefore, Chinese mothers (especially for our participants) in general had a full-time job when their children were 14-month-old. Relatedly, the stress level for working Chinese mothers may have been higher than for Dutch mothers who were able to arrange their work and caregiving tasks in a more flexible way. Although mean-level differences in parental AS and maternal EF were found between the two countries, it is not clear why. Some factors such as parental beliefs and attitudes towards autonomy supportive parenting as well as life stress can be investigated in the future to explore possible underlying processes.

The finding that Dutch infants outperformed Chinese infants on EF was contradictory to previous studies suggesting that Chinese children in general outperformed Western children on EF tasks (e.g., Sabbagh, et al., 2006; Wang et al., 2016). Infant's age may be an

explanation as children in previous studies were older than 3 years, while participants in the current study were 14 months of age. Three-year-old children are normally going to kindergartens or preschools in both countries. It is common for Chinese parents and teachers to highly emphasize self-control or group-based activities among preschoolers. Moreover, Chinese children receive intensive training for skills such as painting and dancing from kindergarten onwards. All of these trainings may contribute to the maturity of EF from preschool age onwards (e.g., Ellefson et al., 2017; Tobin, 2009). Overall, although there were mean-level differences in parent EF, AS, and infant EF in the Netherlands and China, the relation between those three variables was similar across countries.

4.5. Strengths and limitations

There are several strengths of the current study, including the multiple-method design, samples covering both Western and non-Western countries, inclusion of both mothers and fathers as well as multiple indices of child EF. However, a few limitations of this study should be noted. First, the participating families were almost all from middle and high socioeconomic classes, thus our findings may be biased to certain types of families and may not capture the situation in lower socioeconomic backgrounds. As families from lower socioeconomic classes are more likely to experience stress due to unemployment, low education or other reasons, their parental behaviors and child outcomes may differ from middle-to-high socioeconomic backgrounds (Mesman et al., 2012). Second, parent EF was measured with two tasks (i.e. the Hearts & Flowers, the Tower of Hanoi) to test different components of EF, while other studies that showed a significant relation between parental EF and AS or scaffolding used Dimensional Change Card Sort (DCCS) and Flanker (John et al., 2018), or a battery test (i.e., the Stroop color-word task, the Wisconsin Card Sorting Test (WCST), the Tower of Hanoi, and a backward digit span task; Deater-Deckard et al., 2012), or two-word span tests for parental EF (Obradović et al., 2019). The association between parental EF and AS may be found with some assessments but not with others. Overall, further studies are needed to know whether the failure to replicate findings related to associations between parental EF and AS among Chinese fathers and Dutch mothers and fathers is due to the measurement or simply an absence of the phenomenon. Third, the current study did not control for infants' receptive language ability, which could have influenced task performance because all of the tasks used verbal instructions in addition to nonverbal (showing how the task was done). However, a previous study on infants of similar ages and the same EF tasks showed no clear correlations between language ability and the performance of infant EF tasks (Devine et al., 2019).

5. Conclusion

To our knowledge, this is the first study to investigate the parenting mechanism of intergenerational EF in infancy by including mothers and fathers in both a Western and non-Western country. Understanding the precursors of cognitive development and how these associations are characterized across countries and parents are important topics. Overall, parental AS did not mediate the relation between parent EF and infant EF at 14 months. Individual differences in early EF may not be stable enough to be reliably predicted from parental factors. Our findings showed similarities and contrasts across the Netherlands and China. No country differences were found in the relation between parent EF, AS and infant EF. Dutch parents showed higher levels of AS than Chinese parents. Dutch mothers performed better on EF tasks compared to Chinese mothers, and Dutch infants showed higher levels of inhibition than Chinese infants. Future studies are needed to explore the effect of parental characteristics on EF development in infancy as well as preschool age in multiple countries across the globe.

Funding

This work was partly financed by the Netherlands Organization for Scientific Research (NWO) with project number 464-13-141. Financial support from the Institute of Education and Child Studies, Leiden University, the Netherlands is also gratefully acknowledged.

CRediT authorship contribution statement

Wei Li: Conceptualization, Methodology, Investigation, Resources, Writing – original draft, Data curation, Resources, Visualization, Validation, Project administration, **Harold T. Nefs**: Methodology, Formal analysis, Software, Resources, Writing – review & editing, Visualization, Validation. **Rosanneke A. G. Emmen**: Conceptualization, Writing – review & editing, Validation, Supervision, Project administration, **Mi-lan J. Woudstra**: Investigation, Resources, Data Curation, Validation, Project administration, **Marjolein C. E. Branger**: Investigation, Resources, Data curation, Validation, Project administration, **Lamei Wang**: Writing – review & editing, Supervision, **Lenneke R. A. Alink**: Conceptualization, Writing – review & editing, Supervision, Validation, Project administration, Funding acquisition. **Judi Mesman**: Conceptualization, Writing – review & editing, Supervision, Validation, Project administration, Funding acquisition.

Declarations of interest

None.

Data Availability

The data that has been used is confidential.

Acknowledgements

We would also like to thank all the parents and children who participated in this study and students who helped this project.

References

Amodia-Bidakowska, A., Laverty, C., & Ramchandani, P. G. (2020). Father-child play: A systematic review of its frequency, characteristics and potential impact on children's development. *Developmental Review, 57*(June), Article 100924. https://doi.org/10.1016/j.dr.2020.100924

Baddeley, A.D. (2001). *Is Working Memory Still Working?**. https://doi.org/10.1027/1016–9040.7.2.85.

Bernier, A., Carlson, S. M., & Whipple, N. (2010). From external regulation to self-regulation: Early parenting precursors of young children's executive functioning. *Child Development, 81*(1), 326–339. https://doi.org/10.1111/j.1467-8624.2009.01397.x

Best, J. R., & Miller, P. H. (2010). A Developmental perspective on executive function. In *Child Development* (Vol. 81, pp. 1641–1660). John Wiley & Sons Ltd.,. https://doi.org/10.1111/j.1467-8624.2010.01499.x

Bridgett, D. J., Burt, N. M., Edwards, E. S., & Deater-deckard, K. (2015). Multidisciplinary review and integrative conceptual framework. *Psychological Bulletin, 141*(3), 602–654. https://doi.org/10.1037/a0038662.Intergenerational

Bridgett, D. J., Gartstein, M. A., Putnam, S. P., Lance, K. O., Iddins, E., Waits, R., Vanvleet, J., & Lee, L. (2011). Emerging effortful control in toddlerhood: The role of infant orienting/regulation, maternal effortful control, and maternal time spent in caregiving activities. *Infant Behavior and Development, 34*(1), 189–199. https://doi.org/10.1016/j.infbeh.2010.12.008

Browne, M. W., & Cudeck, R. (1992). Alternative ways of assessing model fit. *Sociological Methods & Research, 21*(2), 230–258. https://doi.org/10.1177/0049124192021002005

Chao, R. K. (1994). Beyond parental control and authoritarian parenting style: Understanding chinese parenting through the cultural notion of training. *Child Development, 65*(4), 1111. https://doi.org/10.2307/1131308

Cheah, C. S. L., Li, J., Zhou, N., Yamamoto, Y., & Leung, C. Y. Y. (2015). Understanding Chinese immigrant and European American Mothers' expressions of warmth. *Developmental Psychology, 51*(12), 1802–1811. https://doi.org/10.1037/a0039855

Cheng, N., Lu, S., Archer, M., & Wang, Z. (2018). Quality of maternal parenting of 9-month-old infants predicts executive function performance at 2 and 3 years of age. *Frontiers in Psychology, 8*(JAN), 1–12. https://doi.org/10.3389/fpsyg.2017.02293

Cheung, C. S., Pomerantz, E. M., Wang, M., & Qu, Y. (2016). Controlling and autonomy-supportive parenting in the United States and China: Beyond Children's reports. *Child Development, 87*(6), 1992–2007. https://doi.org/10.1111/cdev.12567

Cuevas, K., Deater-Deckard, K., Kim-Spoon, J., Wang, Z., Morasch, K. C., & Bell, M. A. (2014a). A longitudinal intergenerational analysis of executive functions during early childhood. *British Journal of Developmental Psychology, 32*(1), 50–64. https://doi.org/10.1111/bjdp.12021

Cuevas, K., Deater-Deckard, K., Kim-Spoon, J., Watson, A. J., Morasch, K. C., & Bell, M. A. (2014b). What's mom got to do with it? Contributions of maternal executive function and caregiving to the development of executive function across early childhood. *Developmental Science, 17*(2), 224–238. https://doi.org/10.1111/desc.12073

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia, 44*(11), 2037–2078. https://doi.org/10.1016/j.neuropsychologia.2006.02.006

Dawson, G., Panagiotides, H., Klinger, L. G., & Hill, D. (1992). The role of frontal lobe functioning in the development of infant self-regulatory behavior. *Brain and Cognition, 20*(1), 152–175. https://doi.org/10.1016/0278-2626(92)90066-U

Deater-Deckard, K. (2014). Family matters: Intergenerational and interpersonal processes of executive function and attentive behavior. *Current Directions in Psychological Science, 23*(3), 230–236. https://doi.org/10.1177/0963721414531597

Deater-Deckard, K., Wang, Z., Chen, N., & Bell, M. A. (2012). Maternal executive function, harsh parenting, and child conduct problems. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 53*(10), 1084–1091. https://doi.org/10.1111/j.1469-7610.2012.02582.x

Devine, R. T., Ribner, A., & Hughes, C. (2019). Measuring and predicting individual differences in executive functions at 14 months: A longitudinal study. *Child Development, 90*(5), e618–e636. https://doi.org/10.1111/cdev.13217

Diamond, A. (1985). Development of the Ability to Use Recall to Guide Action, as Indicated by Infants ' Performance on $A\bar{B}$ Author (s): Adele Diamond Published by: Wiley on behalf of the Society for Research in Child Development Stable URL. *Child Development, 56*(4), 868–883. ⟨http://www.jstor.org/stable/1⟩.

Diamond, A. (1988). Abilities and Neural Mechanisms Underlying $A\bar{B}$ Performance Author (s): Adele Diamond Published by: Wiley on behalf of the Society for Research in Child Development Stable URL: ⟨https://www.jstor.org/stable/1130330⟩ REFERENCES Linked references are avai. *59*(2), 523–527.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). The early years: Preschool program improves cognitive control. *Science, 318*(5855), 1387–1388. https://doi.org/10.1126/science.1151148

Distefano, R., Galinsky, E., McClelland, M. M., Zelazo, P. D., & Carlson, S. M. (2018). Autonomy-supportive parenting and associations with child and parent executive function. *Journal of Applied Developmental Psychology, 58*(April), 77–85. https://doi.org/10.1016/j.appdev.2018.04.007

Eason, S. H., & Ramani, G. B. (2017). Parental guidance and children's executive function: Working memory and planning as moderators during joint problem-solving. *Infant and Child Development, 26*(2), 1–24. https://doi.org/10.1002/icd.1982

Ellefson, M. R., Ng, F. F. Y., Wang, Q., & Hughes, C. (2017). Efficiency of executive function: A two-generation cross-cultural comparison of samples from Hong Kong and the United Kingdom. *Psychological Science, 28*(5), 555–566. https://doi.org/10.1177/0956797616687812

Friedman, N. P., Miyake, A., Robinson, J. A. L., & Hewitt, J. K. (2011). Developmental trajectories in toddlers' self-restraint predict individual differences in executive functions 14 years later: a behavioral genetic analysis. *Developmental Psychology, 47*(5), 1410–1430. https://doi.org/10.1037/a0023750

Friedman, N.P., Miyake, A., Young, S.E., Defries, J.C., Corley, R.P., & Hewitt, J.K. (2009). Genetic in Origin. 137(2), 201–225. https://doi.org/10.1037/0096–3445.137.2.201.Individual.

Fritz, M. S., Taylor, A. B., & Mackinnon, D. P. (2012). Explanation of two anomalous results in statistical mediation analysis. *Multivariate Behavioral Research, 47*(1), 61–87. https://doi.org/10.1080/00273171.2012.640596

Garon, N., Bryson, S.E., & Smith, I.M. (2008). *Executive Function in Preschoolers: A Review Using an Integrative Framework*. https://doi.org/10.1037/0033–2909.134.1.31.

Garon, N., Smith, I. M., & Bryson, S. E. (2014). A novel executive function battery for preschoolers: Sensitivity to age differences. *Child Neuropsychology, 20*(6), 713–736. https://doi.org/10.1080/09297049.2013.857650

Grolnick, W. S., & Ryan, R. M. (1989). Parent styles associated with children's self-regulation and competence in school. *Journal of Educational Psychology, 81*(2), 143–154. https://doi.org/10.1037/0022-0663.81.2.143

Hammond, S. I., Müller, U., Carpendale, J. I. M., Bibok, M. B., & Liebermann-Finestone, D. P. (2012). The effects of parental scaffolding on preschoolers' executive function. *Developmental Psychology, 48*(1), 271–281. https://doi.org/10.1037/a0025519

Hendry, A., Jones, E. J. H., & Charman, T. (2016). Executive function in the first three years of life: Precursors, predictors and patterns. *Developmental Review, 42*, 1–33. https://doi.org/10.1016/j.dr.2016.06.005

Hughes, C., & Devine, R. T. (2019). For better or for worse? Positive and negative parental influences on young children's executive function. *Child Development, 90*(2), 593–609. https://doi.org/10.1111/cdev.12915

Hughes, C. H., & Ensor, R. A. (2009). How do families help or hinder the emergence of early executive function. *New Directions for Child and Adolescent Development, 2009*(123), 35–50. https://doi.org/10.1002/cd.234

Hughes, C., & Ensor, R. (2005). Executive function and theory of mind in 2 year olds: A family affair? *Developmental neuropsychology, 28*(2), 645–668.

Huizinga, M., Dolan, C. V., & van der Molen, M. W. (2006). Age-related change in executive function: Developmental trends and a latent variable analysis. *Neuropsychologia, 44*(11), 2017–2036. https://doi.org/10.1016/j.neuropsychologia.2006.01.010

Jester, J. M., Nigg, J. T., Puttler, L. I., Long, J. C., Fitzgerald, H. E., & Zucker, R. A. (2009). Intergenerational transmission of neuropsychological executive functioning. *Brain and cognition, 70*(1), 145–153.

Johansson, M., Marciszko, C., Brocki, K., & Bohlin, G. (2016). Individual differences in early executive functions: A longitudinal study from 12 to 36 months. *Child Dev, 25*, 533–549. https://doi.org/10.1002/icd.1952

(St) John, A. M., Oztahtaci, B., & Tarullo, A. R. (2018). Parental executive function and verbal ability matter for scaffolding. *Journal of Family Psychology, 32*(3), 406–411. https://doi.org/10.1037/fam0000374.

Kao, K., Nayak, S., Doan, S. N., & Tarullo, A. R. (2018). Relations between parent EF and child EF: The role of socioeconomic status and parenting on executive functioning in early childhood. *Translational Issues in Psychological Science, 4*(2), 122–137. https://doi.org/10.1037/tps0000154

Kopp, C. B. (1982). Antecedents of self-regulation: A developmental perspective. *Developmental Psychology, 18*(2), 199–214. https://doi.org/10.1037/0012-1649.18.2.199

Korucu, I., Litkowski, E., Purpura, D. J., & Schmitt, S. A. (2020). Parental executive function as a predictor of parenting practices and children's executive function. *Infant and Child Development, 29*(1), 1–16. https://doi.org/10.1002/icd.2152

Li, W., Devine, R. T., Ribner, A., Emmen, R. A. G., Woudstra, M. lan J., Branger, M. C. E., Wang, L., van Ginkel, J., Alink, L. R. A., & Mesman, J. (2022). The role of infant attention and parental sensitivity in infant cognitive development in the Netherlands and China. *Journal of Experimental Child Psychology, 215*, Article 105324. https://doi.org/10.1016/j.jecp.2021.105324

Li, W., Woudstra, M. lan J., Branger, M. C. E., Wang, L., Alink, L. R. A., Mesman, J., & Emmen, R. A. G. (2019). The effect of the still-face paradigm on infant behavior: A cross-cultural comparison between mothers and fathers. *Infancy, 24*(6), 893–910. https://doi.org/10.1111/infa.12313

Li, X., & Lamb, M. E. (2015). Fathering in Chinese culture: Traditions and transitions. *Fathers Across Cultures: The Importance, Roles, and Diverse Practices of Dads, August, 2016*, 273–306. ⟨https://psycnet.apa.org/record/2015-46469-013⟩.

Malmberg, L. E., Lewis, S., West, A., Murray, E., Sylva, K., & Stein, A. (2016). The influence of mothers' and fathers' sensitivity in the first year of life on children's cognitive outcomes at 18 and 36months. *Child: Care, Health and Development*. https://doi.org/10.1111/cch.12294

Matte-Gagné, C., & Bernier, A. (2011). Prospective relations between maternal autonomy support and child executive functioning: Investigating the mediating role of child language ability. *Journal of Experimental Child Psychology, 110*(4), 611–625. https://doi.org/10.1016/j.jecp.2011.06.006

Mazursky-horowitz, H., Thomas, S. R., Woods, K. E., Chrabaszcz, J. S., Deater-deckard, K., & Chronis-tuscano, A. (2019). *FAMILIES OF CHILDREN WITH AND WITHOUT PARENT, 46*(3), 463–475. https://doi.org/10.1007/s10802-017-0289-2.MATERNAL

McDonald, R. P., & Marsh, H. W. (1990). Choosing a multivariate model: Noncentrality and goodness of fit. *Psychological Bulletin, 107*(2), 247–255. https://doi.org/10.1037/0033-2909.107.2.247

Mcloyd, V.C. (1990). The Impact of Economic Hardship on Black Families and Children: Psychological Distress, Parenting, and Socioemotional Development Author (s): Vonnie C. McLoyd Source: Child Development, Apr., 1990, Vol. 61, No. 2, Special Issue on Minority P. 61(2), 311–34.

Mesman, J., van Ijzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2012). Unequal in opportunity, equal in process: Parental sensitivity promotes positive child development in ethnic minority families. *Child Development Perspectives, 6*(3), 239–250. https://doi.org/10.1111/j.1750-8606.2011.00223.x

Meuwissen, A. S., & Carlson, S. M. (2015). Fathers matter: The role of father parenting in preschoolers' executive function development. *Journal of Experimental Child Psychology, 140*, 1–15. https://doi.org/10.1016/j.jecp.2015.06.010

Miller, S.E., & Marcovitch, S. (2015). *Examining Executive Function in the Second Year of Life: Coherence, Stability, and Relations to Joint Attention and Language*. https://doi.org/10.1037/a0038359.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and Their Contributions to Complex "Frontal Lobe" Tasks: A Latent Variable Analysis. *Cognitive Psychology, 41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Mokrova, I., O'Brien, M., Calkins, S., & Keane, S. (2010). Parental ADHD symptomology and ineffective parenting: The connecting link of home chaos. *Parenting, 10*(2), 119–135. https://doi.org/10.1080/15295190903212844

Mori, Emi, & Liu, Chunyan (2012). Chunyan Liu MD Eliko Otsuki RN RM DNSc Eiko Kashiwabara RN RM MNSc Comparing child-care values in Japan and China among parents with infants. & et. *International Journal of Nursing Practice, 18*, 18–27. https://doi.org/10.1111/j.1440-172X.2012.02025.x

Mullineaux, P. Y., Deater-Deckard, K., Petrill, S. A., Thompson, L. A., & DeThorne, L. S. (2009). Temperament in middle childhood: A behavioral genetic analysis of fathers' and mothers' reports. *Journal of Research in Personality, 43*(5), 737–746. https://doi.org/10.1016/j.jrp.2009.04.008

Obradović, J., Finch, J. E., Portilla, X. A., Rasheed, M. A., Tirado-Strayer, N., & Yousafzai, A. K. (2019). Early executive functioning in a global context: Developmental continuity and family protective factors. *Developmental Science, 22*(5), 1–15. https://doi.org/10.1111/desc.12795

Posner, M. I., & Rothbart, M. K. (2007). Research on attention networks as a model for the integration of psychological science. *Annual Review of Psychology, 58*, 1–23. https://doi.org/10.1146/annurev.psych.58.110405.085516

Rosseel, Y. (2012). lavaan: an R package for structural equation modeling and more Version 0.5–12 (BETA). ⟨http://cran.r-project.org/⟩.

Sabbagh, M.A., Xu, F., Carlson, S.M., Moses, L.J., & Lee, K. (2006). *The Development of Executive Functioning and Theory of Mind A Comparison of Chinese and U.S. Preschoolers*.

Schmitt, S. A., Korucu, I., Napoli, A. R., Bryant, L. M., & Purpura, D. J. (2018). Using block play to enhance preschool children's mathematics and executive functioning: A randomized controlled trial. *Early Childhood Research Quarterly, 44*, 181–191. https://doi.org/10.1016/j.ecresq.2018.04.006

Senn, T. E., Andrews Espy, K., & Kaufmann, P. M. (2004). Using Path Analysis To Understand Executive Function Organization In Preschool Children. *Developmental Neuropsychology, 26*(1), 445–464. https://doi.org/10.1207/s15326942dn2601_5

Shallice, T. (1982). Specific impairments of planning. *Philosophical Transactions of the Royal Society of London Series B, Biological Sciences*. https://doi.org/10.1098/rstb.1982.0082

Singh-Manoux, A., Adler, N. E., & Marmot, M. G. (2003). Subjective social status: Its determinants and its association with measures of ill-health in the Whitehall II study. *Social Science and Medicine, 56*(6), 1321–1333. https://doi.org/10.1016/S0277-9536(02)00131-4

Sun, J., & Tang, Y. (2019). Maternal scaffolding strategies and early development of self-regulation in Chinese preschoolers. *Early Child Development and Care, 189*(9), 1525–1537. https://doi.org/10.1080/03004430.2017.1395874

Tobin, J. (2009). Continuity and Change in Preschool in Three Cultures.: EBSCOhost. *Comparative Education Review*.

Valcan, D. S., Davis, H., & Pino-Pasternak, D. (2018). Parental behaviours predicting early childhood executive functions: a meta-analysis. *Educational Psychology Review, 30*(3), 607–649. https://doi.org/10.1007/s10648-017-9411-9

Volling, B. L., McElwain, N. L., Notaro, P. C., & Herrera, C. (2002). Parents' emotional availability and infant emotional competence: Predictors of parent-infant attachment and emerging self-regulation. *Journal of Family Psychology, 16*(4), 447–465. https://doi.org/10.1037/0893-3200.16.4.447

Vygotsky, L. S., & Cole, M. (1978). Mind in society: Development of higher psychological processes. Harvard university press.

Wang, Z., Devine, R. T., Wong, K. K., & Hughes, C. (2016). Theory of mind and executive function during middle childhood across cultures. *Journal of Experimental Child Psychology, 149*, 6–22. https://doi.org/10.1016/j.jecp.2015.09.028

Welsh, M., & Huizinga, M. (n.d.). *Welsh et al.*

Welsh, M. C., & Pennington, B. F. (1988). Assessing frontal lobe functioning in children: Views from developmental psychology. *Developmental neuropsychology, 4*(3), 199–230.

Whipple, N., Bernier, A., & Mageau, G. A. (2011). Broadening the study of infant security of attachment: Maternal autonomy-support in the context of infant exploration. *Social Development, 20*(1), 17–32. https://doi.org/10.1111/j.1467-9507.2010.00574.x

Wiebe, S. A., Lukowski, A. F., & Bauer, P. J. (2010). Sequence imitation and reaching measures of executive control: A longitudinal examination in the second year of life. *Developmental Neuropsychology, 35*(5), 522–538. https://doi.org/10.1080/87565641.2010.494751

Wood, D. (1980). Teaching the young child: Some relationships between social interaction, language, and thought. In D. Olson (Ed.), The socialfoundations of language and thought (pp. 280-296). Norton.