The Contributions of Preschool Attendance and Kindergarten Experience to Executive Functioning in Chinese and American Children

by

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Abstract

Executive functions (EF), including working memory (WM), attention, and cognitive flexibility (CF), are fundamental to students' academic success, and Chinese children exhibit a substantial advantage in these skills. This project explored this culture gap, as well as cultural differences in the associations between gender, preschool, and kindergarten experiences and EF. In Study 1, 198 American and 196 Chinese children were assessed at the beginning and end of kindergarten in EF skills. Parents reported their socioeconomic backgrounds and children's preschool history. Chinese children were estimated to have spent, on average, over 4,000 hours in preschool, compared to just 1,400 hours in America.

At kindergarten entry, Chinese children outscored American children by 0.80 standard deviations (SD) in attention, 0.62 SD in WM, and 0.47 SD in CF, controlling for SES differences. The attention gap remained the same from fall to spring, but the Chinese advantage grew to 0.95 SD in WM and 0.71 SD in CF. In both cultures, girls outscored boys at kindergarten entry by 0.22 SD in CF, but a female advantage was only present in the U.S. for attention (0.40 SD) and WM (0.44 SD). Preschool had a small positive association with school-entry WM in both cultures ($\beta = 0.17$), an association with attention in China ($\beta = 0.27$), and no association with school-entry CF. However, preschool did have a negative association with girls' CF growth over kindergarten.

In Study 2, researchers observed the same children in their kindergarten classrooms for one hour of a typical school day and coded the time that children spent in academic activities and that teachers spent giving instructions for activities and classroom procedures (labeled *orientation*). Orientation was associated with attention growth in the U.S. ($\beta = 0.24$). Academic activities were associated with CF growth in both cultures ($\beta = 0.11$), attention growth in the U.S. ($\beta = 0.19$), and WM growth in China ($\beta = 0.31$). These findings indicate that the Chinese EF advantage may be partially due to differences in the quantity and content of early schooling and highlight the importance of American investment in early education.

Chapter I

Introduction

In the ongoing effort to improve children's academic achievement in America, accumulating evidence points to the importance of child, family, schooling, and the larger sociocultural contexts in shaping children's academic trajectories. Recently, evidence across a number of disciplines has highlighted the importance of a set of fundamental skills, termed executive functioning (EF), for school success. EF refers to a constellation of skills that underlie a child's ability to maintain and control attention, inhibit inappropriate responses, mentally manipulate information, and plan and execute tasks (Banich, 2009). Recent studies of EF have documented that: (1) differences in children's EF emerge as early as preschool (McClelland, Morrison, & Holmes, 2000), (2) East Asian children demonstrate an early and substantial advantage in these skills (Sabbagh, Xu, Moses, Carlson, & Lee, 2006; Oh & Lewis, 2008), (3) EF is predictive of academic success throughout elementary school (Blair & Razza, 2007; Duncan et al., 2007), and (4) EF skills are malleable (Klingberg et al., 2005; Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008b).

Despite extensive studies on the predictive importance of EF skills, scientists have not reached a consensus on the structure or domain of executive functioning (see Banich, 2009). EF (and related terms such as executive control and self-regulation) has been variably defined as including working memory, inhibition, attentional control, cognitive flexibility, planning, sequencing, decision-making, delay of gratification, and other related skills. Additionally, researchers disagree as to whether EF skills are aspects of one cognitive ability (i.e., Salthouse & Davis, 2006), are initially one skill which begins to differentiate in middle childhood (Wiebe, Espy, & Charak, 2008), or are related but separate skills (i.e., Miyake, Friedman, Emerson, Witzki, & Howerter, 2012).

The current study examines, and treats as separable, three commonly accepted components of executive functioning: working memory, attentional control, and cognitive flexibility. Working memory refers to the ability to maintain information in memory long enough to manipulate or act upon it (as opposed to short-term memory, which is simply the ability to maintain new information in memory for a short time). This skill enables children to understand and follow multi-step directions, make connections between past, present, and future events, and perform cognitive tasks, such as mental math, that require the manipulation of new information. Attentional control, which is the ability to focus and sustain attention on the task at hand while ignoring distractions, is closely related to inhibition (the ability to ignore distraction and suppress a prepotent response; Diamond, 2006). We use the term attentional control here to distinguish this skill from the suppression of a dominant response, which is a common definition of inhibition used in the EF literature (i.e., Miyake et al., 2000).

Cognitive flexibility is the ability to switch flexibly between rules for behavior or attentional foci. This skill requires both working memory and inhibition, as one must both remember multiple rules and inhibit responses that are not aligned with the current rule. Inhibition, attentional control, and cognitive flexibility are essential for success in the classroom, as they enable children to control their behavior, focus their attention, ignore distractions, and switch between tasks and rules in different contexts (Diamond, 2006).

In American children, researchers have consistently found that EF skills predict academic growth (but see Willoughby, Kupersmidt, &Voegler-Lee, 2012, for a counterargument). For example, Blair and Razza (2007) found that inhibition and cognitive flexibility predicted both math and literacy skills in kindergartners. Additionally, Duncan and colleagues (2007) found that attention skills at the beginning of kindergarten predicted math and reading skills in third grade and math skills in fifth grade. Furthermore, a cross-cultural comparison of American and Chinese children found that the association between EF skills and academic achievement was similar in the two cultures, with working memory, attentional control, and inhibition all making unique contributions to academic skills (Lan, Legare, Ponitz, Lee, & Morrison, 2011).

Because of the robust link between EF skills and academic achievement, improving EF skills may play a role in reducing school inequalities, as research has found that children from disadvantaged socioeconomic backgrounds have less well-developed EF relative to their peers from middle- and upper-middle-class families (e.g., Noble, Norman, & Farah, 2005). A growing body of research suggests that executive functions undergo substantial growth and development around the onset of school entry (Diamond, 2006; Welsh, 2001; Zelazo, Craik, & Booth, 2004), which indicates that preschool and kindergarten may be ideal times to target these skills.

Executive functions develop steadily throughout infancy and childhood, but specific periods are associated with rapid development in particular skills. The preschool period is associated with significant improvements in cognitive flexibility, inhibition, and attentional control, while the elementary school years are associated with increases in working memory capacity and further improvements in cognitive flexibility (Diamond, 2006). In a longitudinal study, Hughes, Ensor, Wilson, and Graham (2010) found that scores on a latent EF factor, measured using working memory, inhibition, and planning tasks, grew significantly over the transition to school (from age 4 to age 6).

The rapid development of these skills during early childhood is rooted in maturational factors including increases in neural connectivity and processing speed (Diamond, 2006). Both synaptic formation and pruning processes are active during the preschool years, leading to changes in brain volume and organization. In a review of neurological studies outlining typical brain development, Tau and Peterson (2010) conclude that age-related improvements in working memory, inhibition, and attention coincide with changes in cortical thickness, brain volume, and activation patterns in frontoparietal and frontostriatal neural circuits. However, these physical changes are partially dependent on the environment (Greenough, Black, & Wallace, 1987).

Greenough and colleagues (1987) coined the term *experience-dependent* to describe physical changes in the brain that occur in response to an individual's unique environment. Recently, prospective neuroimaging studies have shown experience-dependent environmental influences on specific brain structures in children. In a sample of institutionalized orphans, Tottenham and colleagues (2010) found that early adoption predicted smaller amygdala size (associated with better emotion regulation). In a complementary study, Lupien and colleagues (2011) found an association between early exposure to maternal depression and larger amygdala volume. Additionally, maternal support during the preschool period has been found to predict larger hippocampal volume (associated with better memory and emotion regulation) at school entry (Luby et al., 2012).

This body of neurological evidence highlights the importance of experience for brain, and as a result, for cognitive development. In recent years, researchers have explored multiple environmental contexts as predictors of cognitive development. For example, Noble, Norman, and Farah (2005) examined the influence of family socioeconomic status (SES) on five neurocognitive systems, finding that SES was associated with performance on measures of the language system, housed in the left perisylvian region, and the executive system in the prefrontal cortex. Studies have also provided evidence of both parenting (i.e., Hughes & Ensor, 2009) and schooling (i.e., Burrage et al., 2008) influences on executive functioning.

The clear role that the environment plays in cognitive development points to the importance of considering context when exploring the growth of executive functions. Bronfenbrenner and Morris (2006) argue that while development is driven by *proximal processes* - interactions between individuals and their environments - the power of these processes to shape development depends on characteristics of the person and of the contexts they encounter at the micro, meso, and macro levels. Because culture, at the macro level, affects meso- and micro-level contexts, including parenting, schooling practices, and interactions between them (Bronfenbrenner, 1979), cross-cultural comparisons provide a fruitful avenue for identifying environmental predictors of EF development.

Psychologists have begun to examine cultural differences in EF skills, finding that East Asian children exhibit substantial advantages over Western children in multiple EF domains in early childhood (Sabbagh et al., 2006; Oh & Lewis, 2008). However, this prior work did not observe children's environments and thus was not able to identify reasons for the observed differences. The current study explores two contextual factors that may be associated with Chinese children's EF advantage at the beginning and end of kindergarten: (1) disparities in preschool experience and (2) differences in the kindergarten classroom environment.

Chapter II

Study 1: The Culture Gap in Executive Functioning and Its Association with Socioeconomic Status, Gender, and Preschool Experience

Individual differences in children's executive functioning skills emerge before children begin formal schooling at age five or six (i.e., McClelland et al., 2000), and these differences predict children's academic achievement over the course of elementary school (Blair & Razza, 2007; Duncan et al., 2007). Multiple child characteristics (i.e., gender, temperament) and environmental factors (including socioeconomic background, parenting practices, schooling, and culture) have been found to predict early EF differences (e.g., Burrage et al., 2008; Conway & Stifter, 2012; McClelland et al., 2000; Noble et al., 2005; Sabbagh et al. 2006). Early education researchers and practitioners have advocated for programs that target these skills in the hopes that gains in EF could translate into better school adjustment and academic success (Blair, 2002; Shonkoff & Phillips, 2000).

Children of disadvantaged socioeconomic status (SES) and boys are particularly at risk for school failure due to sub-optimal EF and self-regulation (Burrage et al. 2008, Noble et al., 2005). However, recent intervention studies have shown that preschool programs can improve EF skills and lead to (at least short-term) improvements in academic skills (Bierman et al., 2008b; Raver et al., 2011). Chinese and American children have both quantitatively and qualitatively different preschool experiences

(Tobin, Hsueh, & Karasawa, 2009), and children in China have more advanced EF skills at ages three and four relative to American children (Lan et al., 2011; Sabbagh et al., 2006). Consequently, these differences in preschool experience may be contributing to the cultural gap in EF skills and may provide a fruitful avenue for the identification of early education practices that promote EF development. The current study explores EF differences in depth in both cultures, examining differential associations among EF skills, SES, gender, and preschool experience.

Socioeconomic Differences in Executive Functioning

Researchers have consistently found that children from families with higher SES outperform lower-SES children on multiple measures of EF (i.e., Noble et al., 2005; Hackman & Farah, 2009). Hughes and colleagues (2010) found that family income predicted children's scores on a latent EF factor (measured by working memory, inhibition, and planning tasks) at age 4 (though income did not predict growth in EF from age 4 to 6). Similarly, a study of kindergartners found that middle-SES (as measured by parental education and occupational status and income-to-needs ratio) children outperformed low-SES children on inhibition and cognitive flexibility (but not working memory) tasks. Additionally, SES accounted for 15% of the variance of the composite EF score. Upon further examination, the researchers found that parental education appeared to drive this relationship, accounting for 12% of the variance in EF when the components of SES were entered separately (Noble et al., 2005).

In an event-related potential study, Stevens, Lauinger, and Neville (2009) used a selective attention task to compare the neurological responses of children whose mothers had at least some college education versus those who did not. The researchers found that, despite no measurable behavioral difference, children of less-educated mothers showed a more pronounced neurological response, relative to the other children, to the information that they were instructed to ignore, indicating that they were having more difficulty inhibiting that input than children of more-educated mothers. Furthermore, cross-cultural work has found that the influence of parental education on preschool inhibition skills is similar in the U.S., Taiwan, and South Korea (Wanless et al., 2011).

Gender Differences

In the United States, multiple lines of research have shown that girls now outperform boys in a variety of academic and cognitive domains, including in executive functioning and related skills. Girls consistently outperform boys on a measure of behavioral self-regulation (the Head-to-Toes/Head-Toes-Knees-Shoulders task) that relies heavily on children's inhibition skills (Ponitz et al., 2008; Ponitz, McClelland, Matthews, & Morrison, 2009). Ponitz and colleagues (2008) found a small advantage for girls (0.08 SD) on this task at age 4 (though no gender difference in growth rate or acceleration). Girls' advantage on this task has also been shown to continue through kindergarten, with boys' scores at the end of the kindergarten year resembling girls' scores at the beginning of the year. In this study, boys' scores at both time points were also more variable, and boys were overrepresented at the bottom of the distribution (Matthews, Ponitz, & Morrison, 2009).

A number of studies have also found that girls have superior learning-related skills (LRS; Matthews, Kizzie, Rowley, & Cortina, 2010, McClelland et al, 2000; Ready, LoGerfo, Burkam, & Lee, 2005). LRS, which refers to a cluster of skills including attentiveness, task persistence, and organization, are thought to be a behavioral manifestation of EF skills (Matthews et al., 2010). A study of a nationally representative sample of African-American kindergartners found that girls outscored boys in teacher ratings of LRS by a margin of 0.44 standard deviations (SD). Girls also outperformed boys in literacy assessments at school entry and showed greater literacy growth over the year (Matthews et al., 2010). Another nationally representative study found that teachers rated girls as higher in both LRS and self-control. Girls' higher ratings on LRS explained 70% of their greater literacy growth, indicating that differences in attention and related skills may partially explain girls' greater literacy achievement in the early grades (Ready et al., 2005). Differences in attention could also be contributing to American girls' demonstrated advantages in mathematics, science, and social studies (Pomerantz, Altermatt, & Saxon, 2002).

Direct assessments of attention in American children converge with the results of teacher-ratings studies, finding that girls develop attention skills earlier than boys (Greenberg & Waldman, 1993; Pascualvaca et al., 1997; Rebok et al., 1997). For example, Rebok and colleagues found that girls showed multiple advantages in measures of sustained and focused attention at age eight, but that many of these gaps dissipated by age thirteen. However, studies of attention in non-American populations do not find the same consistent female advantage seen in American children. A study of school-aged Mexican children did not find any gender difference in attention performance (Brewis, Schmidt, & Casas, 2003), and a study of Taiwanese children and early adolescents found a male advantage for sustained attention (Lin, Hsiao, & Chen, 1999), indicating that the female advantage seen in American children may not be universal.

Studies examining gender differences in working memory and cognitive flexibility have found mixed results. Rebok and colleagues found no gender difference in cognitive flexibility in 8-to-13-year-old children, but a study with older children and adults indicates a female advantage (Kalhut, Han, Lansing, Holdnack, & Delis, 2009). One meta-analysis of results from Wechsler intelligence tests, which included data from both Western and Eastern countries (including the U.S. but not China), found a male advantage in digit span in adults and in mental arithmetic in both older children and adults, but a female digit span advantage in children. The authors interpret these results as indicating that males have better working memory abilities than females, because the mental arithmetic subtest puts greater demand on working memory than does the digit span task (Lynn & Irwing, 2008). However, this interpretation is clouded by other factors influencing performance on the mental arithmetic task, i.e., rote knowledge of arithmetic facts. In contrast, the digit span results indicate that in young children, females have a sizeable working memory advantage (effect sizes for the female advantage in four-to-six-year-olds ranged from 0.31 to 0.42; Lynn & Irwing). In addition, one study of Western adults found greater accuracy (though longer reaction times) for adult females (vs. adult males) on verbal working memory assessments, and different patterns of brain activation for men and women during these tasks (Speck et al., 2000).

We found very few studies of early gender differences in Chinese samples. One study used the Wechsler Intelligence Scale for Chinese Children – Revised (Gong & Cai, 1993) to assess cognitive differences in children 6.5 – 16.5 years old, finding no gender gaps in working memory or most academic skills, though girls showed an advantage in one processing speed task, and boys scored higher in general knowledge and some perceptual reasoning tasks (Lee, 1996). Other researchers have found a similar perceptual/spatial reasoning advantage in Chinese boys (Xu & Zhang, 2000; Zhang et al., 2010). A recent cross-cultural study of young children (ages 3 to 6) found a small female advantage in inhibition for American children, but no gender difference in China, Taiwan, or South Korea (Wanless et al., 2011). These results indicate that American girls are advantaged relative to boys in multiple facets of EF, but that gender gaps in Chinese children are less consistent or non-existent. However, it remains unclear whether there is a Chinese gender gap in attention, or a gender difference in either culture in cognitive flexibility.

The Influence of Schooling Experiences on EF Growth

The findings for the effects of school experiences on EF growth are mixed. To examine the effects of simply attending school on EF development, researchers have used the school cutoff method, comparing children who just made versus those who just missed the age cutoff for school attendance (i.e., children who are virtually the same age but have experienced different amounts of schooling). Using this method, one study found that preschool attendance had no effect on inhibition (Skibbe, Connor, Morrison, & Jewkes, 2010). However, other studies using the same method have found that both preschool and kindergarten had a moderate effect on auditory working memory (η^2 = 0.14) and that preschool had a small effect on inhibition (η^2 = 0.07; Burrage et al., 2008), and that schooling influenced cognitive flexibility in some early elementary grades, but not others (McCrea, Mueller, & Parrila, 1999). Additionally, Cameron and Morrison (2011) found that among children who were attending preschool, those who attended for more hours per week grew more in self-regulation/inhibition skills over the course of the year, though the effect size (0.04) was very small and below Cohen's (1988) cutoff for a practically meaningful effect.

Studies have also examined the effects of specific preschool interventions on children's EF development, finding some encouraging results. Two small-scale randomized trials of the Tools of the Mind curriculum (Bodrova & Leong, 2009) found that program improved preschoolers' inhibition skills (as measured by Flanker-type tasks) and reduced problem behaviors in the classroom (Barnett et al., 2008; Diamond, Barnett, Thomas, & Munro, 2007). The program includes activities, such as dramatic play and buddy reading, which are designed to improve children's self-regulation through social interaction. Contrary to prior findings, a recent large-scale evaluation of this curriculum did not find program effects on any EF skills (Wilson & Farran, 2012). However, this study used different, arguably less "pure" measures of cognitive inhibition (the peg tapping and Head-to-Toes tasks), which may have contributed to the contradictory findings.

The Chicago School Readiness Project, which provides teachers with training in classroom and behavior management, has also been shown to positively affect children's inhibition and attention development (Raver et al., 2011). Additionally, an evaluation of the Head Start REDI (Research Evaluated, Developmentally Informed; Bierman et al., 2008a) program found that children in the intervention group showed greater growth in cognitive flexibility (ES = 0.20, $p = .06$) and task orientation (a behavioral measure involving a large sustained attention component; ES = 0.28, $p < .05$). Additionally, task orientation mediated the effect of the intervention on some literacy skills (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008b). The REDI intervention used a curriculum (Preschool PATHS, or Promoting Alternative Thinking Strategies; Domitrovich, Cortes, & Greenberg, 2007) that includes explicit instruction in social interaction and emotion regulation, which the authors posit relate to EF development by improving children's self-awareness and self-control, and in fact an evaluation of the PATHS curriculum in elementary school classrooms found that the intervention improved children's cognitive inhibition (Riggs, Greenberg, Kusche, & Pentz, 2006). The REDI program also includes an interactive reading component designed to encourage children's reasoning and memory development through narrative recall and comprehension strategies.

Taken together, the findings of these studies indicate that children's executive functioning skills are affected by preschool and school attendance and by specific practices in early education classrooms. These studies have all been conducted using American samples, though, so it remains unknown whether preschool and early schooling experiences influence EF in China or other cultures. However, researchers have found a consistent difference in EF skills between Chinese and American children.

Cultural Differences in Executive Functioning

American visitors to China are often impressed by the effort that Chinese schools expend in socializing attention, as well as in the results of that effort. One of the first delegations of American child psychologists to visit the P.R.C. (Kessen, 1975, p. 107) noted that "one of the most impressive qualities of the Chinese kindergarten children we saw was their ability to sit calmly for long periods of time." These anecdotal reports have been substantiated by quantitative studies. For example, Sabbagh and colleagues (2006) reported consistent differences favoring Chinese 3.5 to 4.5 year old children over their

American peers on a series of inhibition and cognitive flexibility tasks, with Chinese children exhibiting as much as a six-month advantage over American children. Oh and Lewis (2008) found similar gaps favoring Korean over British preschoolers on these tasks, as well as on a working memory assessment. Finally, Lan and colleagues (2011) found large advantages for Chinese versus American preschoolers in inhibition and attentional control (ES = 1.29 and 0.83, respectively), though no difference in working memory.

While these reports point to superior EF skills in young children from multiple Asian cultures, the comparability of the samples in these studies is questionable. First, none of the studies reported specific demographic information, making it impossible to directly compare the socioeconomic backgrounds of participating children. Second, all studies drew their Asian samples from preschools. In Korea, most preschools are private and funded wholly through tuition (Kwon, 2002), which may result in the sample in the Oh & Lewis (2008) study being elite relative to the general Korean population. The authors report that a comparable sample was drawn from Lancaster, UK, but the recruitment mechanism of these participants is unclear. Sabbagh and colleagues (2006) report having drawn their Chinese sample from a preschool serving a middle-class urban area in Beijing and their Western sample from a middle-class university community in the United States, whereas Lan and colleagues (2011) recruited Chinese participants from public preschools in Beijing and American participants from preschools from rural and suburban areas in the Midwest. In China, competition for preschool spots and potentially prohibitive fees (see next section) may make preschool children in Beijing an elite group relative to the general urban Chinese population, which may not be the case in the rural and suburban Midwest. Finally, the predominance of middle-class and professional families in these studies leaves unanswered how children from lower-SES groups from these cultures compare.

Preschool in China and the United States

In the United States, 38% of American three-year-olds and 69% of American four-year-olds were enrolled in some form of preschool in 2010 (U.S. Census Bureau, 2010b). Of American children enrolled in preschool, approximately 60% attend a public program (National Center for Education Statistics, 2011). However, for those without access to public preschool, costs can be quite high. Child Care Aware of America (2011) reported that in 2010, the annual cost of full-time center-based care for a four-year-old ranged from $3,900 to over $14,000. With public programs serving only 17% of three-year-olds and 42% of four-year-olds (National Institute of Early Education Research (NIEER), 2011), and high costs of private care, many American parents are limited to part-time or in-home options. Even when parents have access to public programs, many are only half-day and may not be high-quality. NIEER (2011) estimated that 43% of children in state-funded preschools in 2011 were in programs meeting fewer than half of their quality benchmarks.

In China, "kindergarten" refers to all pre-primary education from age three until first grade, including what in the U.S. is termed "preschool" (for three- and four-year-olds) and "kindergarten" (for five-year-olds). For consistency with American terminology, we will refer to classes for three- and four-year-olds as "preschool" and classes for five-year-olds as "kindergarten." Nationwide, 51% of Chinese children enroll in preschool at age three, and 65% enroll at age four (Li, 2012), and most programs are full-day (Wei, 1993). However, large discrepancies in funding and quality exist among preschools, even within the same city. Public preschools are widely regarded as being of higher quality, due to government subsidies and high-quality teachers (teachers in public preschools receive all the benefits of being a government employee, resulting in high-quality applicants and low turnover rates; Chu, 2009). However, "public" preschools in China are not free. The Chinese government spends less than 2% of its education budget on preschools, and as a result, subsidies do not come close to covering schools' operating costs, requiring preschools to find other ways to supplement their revenue (Chu, 2009; Hu & Li, 2012). Additionally, resource allocation is not equivalent across schools (Chu, 2009). All schools charge a government-approved monthly fee, which can be as low as 200 yuan, but typically is closer to 1,000 yuan or $150 (Kilpatrick, 2010; Song, 2012). 1,000 yuan is 20% of the average household income in urban China (equivalent to an American family paying $1100/month for preschool; National Bureau of Statistics of China, 2011; U.S. Census Bureau, 2010a). In addition, parents report that many schools charge a "sponsorship" or "donation" fee which is necessary to secure a child's spot, making the annual cost for some public preschools upwards of 20,000 yuan (Chu, 2009). The National Development and Reform Commission in China recently issued a ban on public preschool sponsorship fees, but some schools are finding ways to circumvent the rule (Liu, 2012; Song, 2012).

Despite the often high cost of public preschool, many parents are willing to pay if they can secure a spot. Some top preschools in Beijing report having between 7 and 10 times more applicants than they have places (Liu, 2012; Song, 2012). Recent news articles have featured stories of parents and grandparents camping out for days to try to secure a child's place in a public preschool (Li, 2012; China Daily, 2010). In Beijing, licensed preschools (30% of which are public) only have enough spaces for 60% of eligible children (Liu, 2012), forcing many parents to turn to private preschools of varying quality (which can be three to four times more expensive than public) or to unlicensed preschools (which are unregulated and often of poor quality; Chu, 2009; Hu & Li, 2012). Because of the prohibitive cost, many low-income children (estimated at 62% by one study) do not attend preschool or kindergarten, despite the fact that the majority of their parents report a desire to send them (Jin, Liu, Zhang, & Li, 2005). Additionally, some children residing in Beijing are not eligible to attend public preschools (or primary schools), because their parents are migrant workers and do not possess the necessary residency permit for public school attendance. These children are forced to attend unlicensed preschools or not attend at all.

Large gaps also exist between urban and rural areas in terms of access to preschool. One study estimates that fewer than half of children in rural China attend preschool or kindergarten, due largely to a lack of programs in many villages (Luo et al., 2011). Furthermore, rural children lag behind their urban peers at school entry. Luo and colleagues used a Chinese school-readiness test normed on urban children (Ou, 2007), finding that only 6% of rural children scored above the mean, and 57% fell below the cutoff for school readiness. Furthermore, even controlling for family background, rural children who had attended preschool were predicted to score 0.6 standard deviations higher on the readiness assessment than children who had not attended. Taken together, these results indicate that (1) children in urban public Chinese preschools are likely to come from well-off families with highly motivated and involved parents, and (2) these relatively advantaged children may become increasingly advantaged through their participation in full-time high-quality programs. As SES, parenting, and preschool experience are all connected to EF, these compound advantages likely give these children an early edge in these skills.

Differences between American and Chinese Preschools

Both qualitative and quantitative studies indicate differences between American and Chinese preschool environments, which may contribute to Chinese children's observed EF advantage. In the landmark book *Preschool in Three Cultures*, Tobin and colleagues (1989) contrasted an austere, controlled, teacher-centered Chinese preschool with a play-based, child-centered American classroom. In a revisiting of this study, the authors found that though preschool had changed in both cultures, differences still remained; the authors likened American and Chinese preschools to "passing like two ships in the night" (Tobin et al., 2009, p.232). In American preschools, Developmentally Appropriate Practices (Bredekamp, 1987), which emphasize choice and child-centered activities over teacher-directed instruction, are still a driving force. However, teachers are increasingly focused on providing direct instruction, particularly in literacy (Tobin et al., 2009).

Chinese preschools have begun to incorporate child-centered philosophies into their curricula, but didactic instruction and a focus on critique and self-improvement remain central (Tobin et al., 2009). Chinese education is guided by Confucian learning principles, which teach humility and respect for teachers and taking control of one's intellectual and moral development through a constant striving for self-improvement (Li, 2003). These principles are reflected in Chinese children's attitudes towards learning, which could translate into improvements in EF skills. Li (2004) found that Chinese children, when responding to a story about learning behaviors, focused on diligence, persistence, and concentration, whereas American children tended to put more focus on ability and strategy use.

Asian preschoolers' EF advantage over Western preschoolers may also be connected to classroom management practices that promote the development of EF. For example, Lan and colleagues (2009) analyzed teacher instructions in first-grade mathematics classrooms in China and the U.S., drawing a distinction between *preparatory* instructions that occur before a misbehavior (i.e., "Pay attention" when beginning to give directions) and *correctional* instructions that occur after a misbehavior (i.e., "Raise your hand" after a student has called out.). The results were striking: 70% of instructions given by Chinese teachers were preparatory, whereas 70% given by American teachers were correctional. Providing children with more preparatory and fewer correctional instructions may facilitate EF development, as this arrangement requires them to attend to and remember the instructions and then regulate their own behavior during the task.

The Current Study

This study examines EF skills at the beginning and end of kindergarten in American and Chinese children, seeking to clarify previous cross-cultural findings by collecting specific demographic data, so that sample equivalence can be evaluated. We also aim to broaden previous findings by including children from low-income backgrounds in both cultures and by assessing children at two time points, so that cultural differences in growth can be assessed. As researchers have found that children with weaker EF skills catch up over the transition to school (Hughes et al., 2010), we expect that American children will begin to catch up with Chinese children over the course of the kindergarten year.

Additionally, this study examines similarities in SES-EF, gender-EF, and preschool-EF associations, primarily established with Western samples, in the two cultures. We expect that in both cultures, socioeconomic indicators, particularly parental education, will predict children's kindergarten-entry and growth in EF skills. In the U.S., we expect that girls will outperform boys in all skills at kindergarten entry, though it is unclear whether these gender differences will emerge in the Chinese sample and if so, if the gaps will be similar in size to those observed in the U.S. Additionally, we anticipate that more time spent in preschool will predict kindergarten-entry EF skills in both cultures, though it is not clear whether preschool attendance will result in greater EF growth over the kindergarten year. However, these associations may differ between the cultures, as children in the U.S. and China have both quantitatively and qualitatively different preschool experiences. Finally, we will explore potential gender by preschool interactions, though we make no specific predictions about the direction of these effects. The typical classroom environment (at least in the U.S.) is often portrayed as favoring girls (Gurian & Stevens, 2005), and if this is in fact the case, preschool may serve to widen the gender gap in EF skills as girls reap more benefits from the classroom environment. In contrast, it is also possible that preschool serves to foster EF in boys, enabling them to close the gender gap in these skills.

Research Questions

1. How large is the culture gap in EF skills at kindergarten entry, controlling for

family background factors?

   a. Hypothesis 1a: Chinese children will show substantial advantages in attention and cognitive flexibility, but these gaps may be smaller after controlling for SES.
   b. Hypothesis 1b: Chinese children will show a small or negligible advantage in working memory.

2. Do Chinese and American children show similar growth in EF over the kindergarten year?
   a. Hypothesis 2: American children will show greater growth than Chinese children.
3. Do socioeconomic factors predict EF similarly in both cultures?
   a. Hypothesis 3: SES will have the same association with EF in both cultures, with parental education emerging as the most consistent predictor.
4. Is the gender gap in EF skills similar in the U.S. and China?
   a. Hypothesis 4: American girls will outperform American boys in all three skills, but the gender gap will be smaller or non-existent in China.
5. Does preschool attendance predict kindergarten-entry EF skills and EF growth in both cultures?
   a. Hypothesis 5a: Preschool attendance will predict school-entry skills in both cultures, but effects may not carry over into an advantage in growth over the kindergarten year.
   b. Hypothesis 5b: Preschool attendance will have a stronger association with

EF skills in China.

6. Does the association between preschool attendance and EF skills or EF growth vary by gender?

Method

Participants

Children were recruited through their kindergarten classrooms. In both cultures, we attempted to include a diverse sample of schools but were limited by time and resources. As a result, the schools are a convenience sample drawn from districts in which researchers had contacts and which were open to participating in the study. In China, classrooms came from 7 public kindergartens in Beijing and 1 migrant school (a privately-funded school set up for children of migrant workers who are not legal residents of Beijing). The public kindergartens were all three-year pre-primary programs which were not affiliated with primary schools. They all had an above-average quality rating (the norm for most public kindergartens) and charged between 10,000 and 20,000 yuan per year (including monthly and all sponsorship fees). All children were in the final year of the kindergarten program ("big kindergarten"). Because of time and resource constraints, only 15 children per classroom could be included in the Chinese sample. If fewer than 15 children consented, they were all included. If more than 15 consented, participants were randomly selected using a random number generator (www.random.org). In order to achieve a more diverse sample, the classroom from the migrant school was oversampled and included 21 children. The final Chinese sample included 196 Chinese children in 14 classrooms in Beijing, with 9 – 21 participating children per class.

American classrooms were drawn from 10 public schools in the Midwest, 7 of which received Title I funding. Participation in American classrooms was limited to 13 children per class due to time and resource constraints; the sampling procedure was identical to that used in China. The original sample included 212 American children in 21 classrooms in the Midwest. However, data from nine American children were excluded from analyses because they did not speak English well enough to complete the assessments. Additionally, because this study examines kindergarten-entry skills, five American children repeating kindergarten were not included. Thus the final American sample consisted of 198 children (5 – 13 participating children per class), including six pairs of twins.

In China, 17 students were not available for the spring assessments because their families had moved to a different school district (n = 7) or because their parents were migrant workers who had left the area (n = 10). In the U.S., seven students were not available for the spring assessments because they had moved to a different district. However, because multiple imputation was used to recover missing data (see *Results* section), the full sample was retained. Detailed descriptive information about the sample is provided in the *Results* section (see pages 31-33 and Tables 1.1 and 1.2).

Procedure

Children's EF, literacy, and mathematics skills were assessed in two 30-minute individual sessions during the first two months of kindergarten and again during the last two months. With the exception of literacy, all skills were tested using the same assessments (originally developed for English-speaking children in Western countries) in both cultures. The assessments and instructions were translated into Mandarin Chinese, back-translated into English, and then adjusted as necessary to maintain the same meaning in both languages. Assessors in both countries were trained in English by the same researcher, with translation provided as needed for the Chinese assessors. Parents completed a self-administered questionnaire covering the family's demographic information, their educational backgrounds and occupations, and their child's childcare and preschool history. Because not all parents in the U.S. spoke English fluently, some parents completed the questionnaire in Spanish or Arabic, and their responses were translated into English.

Measures

Parents' education, occupation, and income.

Parents were asked, via questionnaire, to select both the mother's and father's highest level of education from a list of options. If the parent had not graduated from high school, they were asked to indicate the last grade completed. If the parent had attended college or graduate school, they were asked to list the degree earned. These responses were coded into estimated years of education, following the guidelines provided by the Programme for International Student Assessment (PISA, 2003; see Table 1.3).

Parents were also asked to list their occupation and to indicate whether or not they were currently employed. Occupations were assigned a score from the International Socio-Economic Index of Occupational Status (ISEI; Ganzeboom, De Graaf, &Treiman, 1992). This scale maximizes the association between education and income. Possible scores range from 10 (kitchen assistants and agricultural laborers) to 90 (judges).

Occupations were scored using the most specific category possible. Some parents' answers (i.e., self-employed) were too vague to be scored and were left as missing values. Additionally, those who listed "student" or "homemaker" and those who indicated that they were unemployed and did not provide a prior occupation were not assigned a score. The higher of the two parents' scores was used in the analysis.

Parents' incomes were summed to create an estimate of household income. Parents who listed that they were unemployed, students, or homemakers were assumed to have no income unless they indicated otherwise. Six families in the U.S. and four families in China reported having no parental income; these families were assigned values equal to the lowest reported incomes in their culture ($5,000 in the U.S. and 2,000 yuan in China). Incomes were then adjusted for regional differences in cost of living in order to reflect purchasing power. American household incomes were multiplied by 1.08 (Aten & D'Souza, 2008) to reflect the relatively lower cost of living in this region; Chinese incomes were multiplied by 0.80 (Gong & Meng, 2008) to reflect the higher cost of living in Beijing relative to other urban areas. In order to make the income values comparable across countries, adjusted household incomes were transformed by first dividing by the appropriate country's mean income and then taking the natural log (see Ganzeboom et al., 1992). This transformation equates families' relative income status within their country (i.e., a family that earns twice the mean American income and a family that earns twice the mean Chinese income have the same transformed score).

Preschool attendance.

Parents reported all out-of-home childcare experiences since age three, listing the type of care, the dates attended, and the average hours per week. This information was used to estimate the total number of hours of preschool that each child experienced. In addition to traditional preschool and Head Start programs, daycare and primary school preparation programs (China only) were included. Dates of attendance were used to calculate the total number of months attended beginning at age 36 months. For preschool, Head Start, and primary school preparation programs, July and August were not counted, as most preschools in Beijing and in our region of the U.S. do not operate during these months. Thus a child who was listed as having attended preschool from September 2009 - September 2010 was assumed to have attended for 10 months. The number of months attended was then multiplied by 4.35 (the average number of weeks per month), to calculate the number of weeks attended, and then by the hours per week of attendance, to create the estimate of total hours of preschool.

Mathematics.

In both cultures, mathematics comprehension was assessed using the Applied Problems subtest of the WJ (Mather & Woodcock, 2001), in which children count objects and use addition and subtraction to solve word problems. Children were given one point for each correct answer.

Executive functions.

EF skills were assessed using three tasks: the WJ pair cancellation task, an auditory working memory task based on the WJ task (Woodcock & Mather, 2000), and the advanced Dimensional Change Card Sort (DCCS; Zelazo, 2006). In the WJ pair cancellation task, children are presented with rows of pictures of dogs, balls, and cups and are asked to circle all the ball-dog pairs in 3 minutes. This task assesses attentional control by requiring children to ignore irrelevant pictures and focus only on the target objects. Children were given 1 point for each correct pair circled.

In the auditory working memory task, children must remember increasingly long lists of objects and numbers, presented in a fixed intermixed order, and repeat the list in order by category (first all the objects, then all the numbers; Woodcock & Mather, 2000). The task was modified so that all test words would have the same number of syllables in both English and Mandarin and would be similarly familiar to children in both cultures. Children were given 2 points for an item if both the objects and the numbers were presented in the correct order, 1 point if either the objects or the numbers, but not both, were presented correctly, and 0 points of neither the objects nor the numbers were presented correctly or if the numbers were given before the objects. These item scores were then summed to a possible total of 42 points.

The advanced DCCS is a test of cognitive flexibility. Children were required to switch between rules for sorting cards in three phases: the color game, the shape game (switching to a new rule) and the border game (switching between 2 rules; Zelazo, 2006). Children were presented with 2 target cards, a red rabbit and a blue boat, and given a set of cards containing only blue rabbits and red boats. Children were first asked to sort the cards by color ("the color game"), putting red boats in front of the red rabbit and blue rabbits in front of the blue boat. Children were then asked to switch and "play the shape game" and match the cards by shape instead of color. If children sorted at least 5 of 6 cards correctly in the shape game, they were passed on to the more difficult "border game." In this game, they were presented with 12 cards, half of which had borders around them, and told that if a card had a border, they should play the border game, and if the card did not have a border, they should play the shape game. Children were given 1 point for each card sorted correctly in the shape game and 1 point for each card beyond 6 correctly sorted in the border game (a score of 6 occurs when a child either sorts by border, by shape, or by color, without switching between rules), for a possible total of 12 points.

Teacher ratings.

Children's EF and motivation were assessed using a self-administered teacher questionnaire. The EF scale consisted of 11 items measuring children's attention and working memory, rated on a 1 (strongly disagree) to 7 (strongly agree) scale. Items included "is prone to disturb other children" and "follows two-step instructions." The motivation scale consisted of 5 items rated from 1 (does not describe this child at all) to 5 (describes this child very well) and included items such as "tackles new activities with enthusiasm" (Fantuzzo, Perry, & McDermott, 2004). These scales were translated into Mandarin and then back-translated into English, with any necessary adjustments made to the Chinese version to maintain the same meaning in both languages. All scales were highly reliable in both cultures (Cronbach's alpha for the U.S. and Chinese samples was .96 and .94 for attention, .92 and .83 for working memory, and .92 and .87 for motivation, respectively).

Results

Missing Data

In China, 98% of families returned their questionnaires, but in the U.S., only 76% of families did. This imperfect return rate, in combination with individual item non-responses, resulted in missing data rates of up to 60% for some background variables. Additionally, more than a quarter of the American children were not able to understand the instructions of the working memory task, and thus were not able to complete the assessment (see Table 1.4).

There are currently two state-of-the-art techniques for handling missing data: full information maximum likelihood (FIML) and multiple imputation (for a full discussion of both techniques, see Enders, 2010). FIML does not allow missingness on predictors and therefore was not an option for this analysis, as the background variables had missing observations. In multiple imputation, missing value handling and data analysis are separate steps, allowing for missingness on predictors (Enders, 2010).

Multiple imputation uses an iterative Bayesian procedure to create multiple copies of the data, each with different plausible values (based on the associations among the variables) for the missing observations. Results are then averaged over these datasets to create the best estimate of each parameter, and standard errors are adjusted for the additional uncertainty due to missing data. Results from multiply imputed data are unbiased as long as the data are missing at random (MAR), meaning that the probability of missingness on a variable is not related to the values of the variable itself (Enders, 2010). In the current study, the MAR assumption may have been violated because parents of lower SES may have been less likely to return their questionnaire, and thus the probability of missingness on SES variables may be related to the values of those variables. Additionally, children who were unable to complete the working memory assessment were likely to have had lower scores, on average, than children who were able to complete it. However, bias from violations of the MAR mechanism can be substantially reduced by including other variables that are related to the variable with missing values (Enders, 2010). Because of the inclusive analysis strategy used (see description below), any bias is likely to be minimal.

Imputations were conducted separately for the American and Chinese samples in order to maintain the separate covariance structures within the cultures. All analysis variables were included in the imputation, as well as a preschool by gender interaction term. In addition, mothers' and fathers' individual incomes were included, as some families reported only one parent's income. The individual components used to create the preschool attendance variable were also included, as some parents indicated that the child had attended preschool, but gave no further information, or listed the months of attendance but not the hours per week. Finally, four additional fully observed auxiliary variables (children's math scores and teachers' ratings of children's attention, working memory, and motivation) were included to improve the prediction of missing EF scores. The imputation models were identical in both cultures with two exceptions: (1) because migrant status was used as a control in the analysis of Chinese data, it was included in the imputation for that culture; and (2) in China, months of preschool was almost perfectly correlated with total hours of preschool, so preschool months was removed to avoid model non-convergence due to multicollinearity.

The imputation used a two-level model to account for the nesting of children in classrooms, which enabled the use of the classroom means of SES variables to inform the imputation of missing individual SES scores. All variables were allowed to correlate with each other at both the within- and between-classrooms level. The imputation was conducted in Mplus version 6.1 with 100,000 iterations of the Gibbs sampler algorithm using two Markov chains with uninformative prior distributions (Muthén & Muthén, 2010). Time-series plots of variables with high rates of missingness were examined to verify that parameter estimates had reached a stable pattern and exhibited minimal autocorrelation (Enders, 2010). Ten imputed data sets, each separated by 200 iterations, were used for analysis.

Analyses

Analyses were conducted in HLM version 6.8, to account for the sampling of children from classrooms (Raudenbush & Bryk, 2002). With the exception of household income, all continuous variables were standardized in the full sample. Spring EF scores were standardized using the mean and variance from the corresponding fall score, so that growth and changes in variation could be observed. Household income was left in the original transformed scale so that zero represented a child whose household income, adjusted for cost of living, was equal to the mean household income for their country. Gender (female=0, male=1) and migrant status (no=0, yes=1) were entered grand-mean centered, so that the model intercepts were not specific to one group. Migrant status was entered at the classroom level, as all migrant children in our study were in the same class. Culture (US=0, China=1) was entered at the classroom level and was left uncentered so that model intercepts represent predicted scores in the U.S.

Descriptive Statistics

The American children (49% female) averaged 63.5 months old at the beginning of kindergarten, and 77% of those reporting ethnicity were Caucasian (see Table 1.1). Disability status was obtained for 134 (68%) of the American children. Of those reporting, two had a diagnosed developmental delay and one had diagnosed Attention-Deficit-Hyperactivity Disorder (ADHD). American mothers were an average of 35 years old with 14 years of education; fathers were 37 years old and had 14 years of education on average (see Table 1.2). Ninety-three percent of reporting families listed that at least one parent was employed; average reported household income, adjusted for cost of living, was $77,957, 14% above the national average for 2010 ($68,259; U.S. Census Bureau, 2010a). Of those reporting an occupation, American parents had average status scores near 50 (on a scale of 10 – 90), which is in the score range for those in sales and for clerical workers.

The Chinese children (52% female) were, on average, 64.9 months old at the beginning of kindergarten (significantly, though only slightly (1.4 months), older than American children), and 88% of those reporting were of Han ethnicity, which is the majority ethnicity in China (see Table 1.1). Disability status was not obtained for the Chinese children, but because children with diagnosed delays or disabilities (including ADHD) typically do not attend regular kindergartens (Hu & Szente, 2010b), it is unlikely that any children in our sample had a diagnosis. Chinese mothers averaged 35 years old at the time of the study and had a mean of 14 years of education (the equivalent of an associate's degree); fathers were 38 years old and had an average of 15 years (significantly more than American fathers; see Table 1.2). Ninety-six percent of reporting families indicated that at least one parent was employed; average reported household income, adjusted for cost of living, was 92,769 yuan, which is 53% higher than the estimated household income for urban Chinese in 2010 (60,576 yuan; National Bureau of Statistics of China, 2011). Of those reporting an occupation, Chinese parents had an average occupational status score of 60, which is the score range for those in civil services and human resources and is significantly higher than American parents' average scores.

To further examine the background of the families, we divided the sample into low-, middle-, and high-education groups (those in which neither parent had a high-school diploma; at least one parent had a high-school education, some college, or an associate's degree; and at least one parent had a college degree, respectively). In the U.S. sample, 12% of reporting families fell into the low-education group, 42% were in the middle group, and 46% were in the high-education group. In China, 25% were in the low group, 14% in the middle, and 60% in the high group. Though the average parental education level did not differ significantly, the Chinese sample contained more participants from both the lower and higher ends of the education distribution.

In both cultures, fathers had high rates of employment regardless of educational grouping. However, mothers' employment rates increased with the family's level of education, and in each educational group, Chinese mothers had higher rates of employment than did American mothers (77 vs 50% for the low group, 88 vs. 59% for the middle group, and 97 vs. 76% for the high group). In the low-education group, typical employment for American parents included working in restaurants/markets and for fathers, low-level skilled occupations (i.e., painter, construction worker). Average reported household income for Americans in this group, adjusted for cost of living, was $41,000, 40% below the national average. Chinese parents in the low-education group often reported being self-employed or in a service industry; other listed occupations included agriculture, business, and sales. Average reported income was about 50,000 yuan, 17% below the national average.

In the middle-education group, American parents typically reported being in the service industry, being technicians or technical assistants, or being in low-level skilled occupations; Chinese parents often listed white-collar jobs such as "company employee" or banking/accounting. American families' average income ($58,000) was 15% below the national mean, whereas Chinese families' average income (93,000 yuan) was 55% above the national mean. In the high-education group, the majority of American parents reported being managers, teachers, or other professionals, with a mean household income of $107,000, 57% above the national average. Engineer, doctor, teacher, and civil services were commonly listed professions for Chinese parents, with a mean household income of 114,000 yuan, 90% above the national average.

Of families reporting, 95% of American parents indicated that the child had attended preschool or daycare, and 99% of Chinese parents indicated attendance. On average, children in both cultures attended for between one and two years. However, almost all children in China attended full-time (40-50 hours per week), whereas attendance hours varied greatly in the U.S., with a mean of only 16 hours per week. As a result, Chinese children were estimated, on average, to have experienced over 4,000 hours of preschool, but American children experienced, on average, just under 1,400 hours (see Table 1.5).

Unstandardized and standardized descriptive statistics for the three EF assessments are presented separately by culture in Table 1.6. In both cultures, kindergarten EF skills were moderately correlated and exhibited a fair degree of stability from fall to spring (correlations between assessments ranged from .16 to .53 and between time points within assessments from .37 to .61; see Table 1.7). Intraclass correlations (ICCs) for the kindergarten-entry skills were moderate (ranging from .14 to .24), indicating that between 14 and 24% of the variance in these skills existed at the classroom level. However, controlling for culture reduced the ICCs to between .07 and .17 (see Table 1.8). ICCs for the kindergarten-exit skills were calculated controlling for fall scores, so that the percentage of variance in growth could be estimated. Again, ICCs for EF growth were moderate (.11 to .35), but were substantially reduced by controlling for culture (to .03 - .25; see Table 1.8).

Research Question (RQ) 1: How large is the culture gap in EF skills at kindergarten entry, controlling for family background factors?

In order to compare our results with previous analyses, we first estimated the culture gap in kindergarten-entry skills controlling only for age, using three hierarchical models (one for each outcome). In these models, Chinese children were predicted to outscore American children by 0.79 SD in attention, 0.59 SD in working memory, and 0.54 SD in cognitive flexibility (see Table 1.9). We subsequently re-estimated these models with added controls for parental education and occupation and household income. Parental education was a significant predictor of all three outcomes, but occupation and income did not make unique contributions. After controlling for SES, the estimated culture gap remained essentially unchanged for all three skills (attention gap = 0.80 SD, working memory gap = 0.62 SD, cognitive flexibility gap = 0.47 SD; see Table 1.10).

RQ 2: Do Chinese and American children show similar growth in EF over the kindergarten year?

To estimate cultural differences in EF growth over the year, we created three hierarchical models (one for each spring outcome), controlling for the child's fall score on the respective skill, age, family background, and the time between fall and spring assessments. Parental education was again a consistent predictor of growth, and income predicted growth in attention (see Table 1.11). To compare the average skills of Chinese and American children at the end of kindergarten, we calculated the predicted spring scores for a child with the average pretest score for his or her culture, holding age, time between tests, and socioeconomic variables constant at the sample mean. The gap in spring attention scores (0.80 SD) was identical to the fall attention gap, indicating that Chinese and American children grew at the same rate. However, the Chinese advantage was moderately larger in the spring in both cognitive flexibility (0.71 vs. 0.47) and in working memory (0.95 vs. 0.62), indicating greater growth in these skills over the kindergarten year (see Figure 1.1).

To follow up on these results, we compared the mean scores for the U.S. sample to the mean scores for the Chinese migrant students, who are disadvantaged relative to the general urban Chinese population (more than half of migrant students in our sample did not have a parent with a high school diploma, and only one migrant family reported a parent having a college degree). The migrant students' mean scores on most assessments were very similar to the mean for the full U.S. sample. Additionally, we separated each sample into subgroups based on the highest parental educational attainment: less than high school (< 12 years of education), high school diploma or associate's degree (12-14 years), college degree or some graduate school (16-17 years), and graduate school (18+ years). Within each subgroup, Chinese children outscored American children. The size of the culture gap was fairly consistent across subgroups, though for fall cognitive flexibility and spring attention, the gap was noticeably larger for children whose parents had not finished high school (2.67 points vs. the overall mean of 1.37 for CF and 11.21 vs. 7.52 points for attention; see Table 1.12).

Cultural Differences in SES, Gender, and Preschool Associations with EF

To examine associations between gender and preschool and kindergarten-entry EF skills, we created hierarchical models controlling for age, parental education, and household income (occupation was removed for parsimony as it did not contribute unique variance to any outcome in previous models). Analyses examining growth in EF skills included the same controls, as well as the child's scores on all fall EF assessments (with the exception of fall cognitive flexibility predicting spring attention, which was removed for parsimony due to non-significance) and the time between fall and spring assessments. Cultural differences in SES, gender, and preschool associations with EF were tested by entering Culture as a predictor of the within-classrooms slopes, but slopes were left fixed, as we were interested only in cultural differences, not in examining random variation by classroom. Initial models included an interaction between culture and all background variables, age, preschool, and gender, and a three-way interaction between preschool, gender, and culture. Models were then made successively more restrictive by removing interaction terms one at a time based on the highest p-value, until all remaining interaction terms were significant at $\alpha = .10$.

RQ 3: Do socioeconomic factors predict EF similarly in both cultures?

Parental education was a positive predictor of kindergarten-entry working memory and cognitive flexibility in both cultures ($\beta = 0.21$, $p < .01$; $\beta = 0.16$, $p < .01$, respectively). However a marginally significant interaction between parental education and culture ($\beta = 0.22$, $p < .10$) indicated that after controlling for preschool, parental education was only a positive predictor of school-entry attention in China (ES = 0.20, $p < .01$; see Table 1.13). Income had no association with school-entry attention in the U.S.

but had a small negative association with attention in China (ES = -0.14, $p < .05$) and had a small negative association with working memory in both cultures (ES = -0.17, $p < .05$), after controlling for parent education.

Parental education was a small positive predictor of growth in working memory and cognitive flexibility in both cultures ($\beta = 0.13$, $p < .05$; $\beta = 0.11$, $p < .10$, respectively). Whereas parental education predicted kindergarten-entry attention in China but not the U.S., the reverse was true for attention growth: parental education was a positive predictor in the U.S. ($\beta = 0.25$, $p < .05$), but not in China ($\beta_{\text{parental education x culture}} = -0.22$, $p < .05$). Income predicted growth in attention and cognitive flexibility in both cultures ($\beta = 0.16$, $p < .01$; $\beta = 0.19$, $p < .10$, respectively; see Table 1.14).

RQ 4: Is the gender gap in EF skills similar in the U.S. and China?

In both cultures, girls outperformed boys in kindergarten-entry cognitive flexibility ($\beta = -0.22$, $p < .01$). Girls also demonstrated an advantage in school-entry attention and working memory in the U.S. ($\beta = -0.40$, $p < .01$; $\beta = -0.44$, $p < .01$, respectively) but gender by culture interactions indicated that this gender gap was not present in China ($\beta = 0.48$, $p < .01$; $\beta = 0.30$, $p < .10$, respectively; see Table 1.13 and Figure 1.2). Gender had no association with EF growth in either culture (see Table 1.14).

RQ 5 and 6: Does preschool attendance predict kindergarten-entry EF skills and EF growth in both cultures? Does the association between preschool attendance and EF skills or EF growth vary by gender?

Preschool exhibited a small positive association with kindergarten-entry working memory skills in both cultures ($\beta = 0.17$, $p < .01$), but no association with cognitive flexibility in either culture. Preschool also had no association with school-entry attention in the U.S., but a preschool by culture interaction indicated that preschool had a positive association with attention in China ($\beta = 0.27$, $p < .10$; see Table 1.13 and Figure 1.3). Preschool did not interact with gender to predict any school-entry skills. After controlling for preschool, the predicted culture gaps in kindergarten-entry EF skills dropped to 0.49 SD for attention, 0.41 SD for working memory, and 0.38 SD for cognitive flexibility (see Table 1.13).

No main effect of preschool was found for growth in any outcome. However, significant interaction effects for gender by culture ($\beta = -0.80$, $p < .05$) and gender by preschool ($\beta = 0.46$, $p < .01$) in the cognitive flexibility model signified a complex relation among these variables (see Table 1.14). In interpreting these results, it is important to keep in mind that the Chinese and American samples differed substantially in both the means and variances of preschool attendance. Therefore, the point estimates calculated for the interpretation of these interactions use the within-culture means and standard deviations, so that below-average refers to 1 within-culture SD below the respective culture's mean, and above-average refers to 1 within-culture SD above the culture's mean.

In both cultures, boys were predicted to have slightly better spring cognitive flexibility scores, controlling for fall, if they had above-average time in preschool. In contrast, girls were predicted to have substantially lower spring scores with more time in preschool (see Figure 1.4). After controlling for preschool, the culture gaps in attention and working memory growth were largely unchanged, but the gap in cognitive flexibility growth dropped from 0.52 to 0.22 SD.

Discussion

The Culture Gap

Harold Stevenson and colleagues (1986) established almost three decades ago that East Asian children were more advanced than American children in both mathematics and reading. Data from international assessments confirms that the United States continues to lag behind China and other East Asian countries (PISA, 2009). In recent years, researchers have identified an even earlier gap: Chinese children's greater EF performance in the preschool years. Our culture gap estimates are largely in line with previous findings, and contrary to our expectations, were not substantially diminished by adjusting for socioeconomic differences. With or without controlling for SES, Chinese children were predicted to score 0.80 SD higher than American children in attentional control, which is almost identical to Lan and colleagues' (2011) estimate (0.83 SD). We also found, even after controlling for SES, a Chinese advantage in cognitive flexibility (CF; 0.47 SD), as did prior studies (Oh & Lewis, 2008; Sabbagh et al., 2006). Because these studies did not report effect sizes, it is difficult to compare the magnitude of our results. However, Sabbagh and colleagues estimated that Chinese children were six months ahead of American children in a composite measure comprised of inhibition and CF tasks. In our data, 0.47 SD is roughly equivalent to six months of growth, indicating that our findings are similar to these authors' in magnitude.

Our working memory findings do diverge somewhat from previous results. Contrary to our hypothesis, we found that Chinese children had an advantage of 0.62 SD after controlling for SES, which by Cohen's (1988) guidelines is considered a moderate effect. In contrast, Oh and Lewis (2008) report finding only a small Chinese advantage, and Lan and colleagues (2011) found no cultural difference. We also predicted that American children would outgrow Chinese children in EF skills over the year, but our results provide evidence that in fact, Chinese children are developing working memory and cognitive flexibility at a faster rate than American children in kindergarten. Controlling for family background, the gaps between Chinese and American children were predicted to grow by 0.24 SD in working memory and 0.33 SD in cognitive flexibility.

Because prior studies all recruited their Asian participants from preschools in affluent areas and did not report specific demographic data, we were concerned that the culture gap in these studies had been overestimated. Our data indicate that these concerns may have been unfounded. Though parental education was a consistent predictor of kindergarten-entry skills, controlling for this factor and other socioeconomic indicators did not substantially reduce the predicted culture gap. Additionally, our culture gap estimates calculated with controls for background differences are either very similar to or larger than previous estimates. However, these findings should be interpreted with caution, because although we did control for background differences, our Chinese sample was largely drawn from similarly affluent preschools as those used for prior studies.

Our Chinese sample, on average, came from families with higher household incomes and occupational status than our American sample, and it is possible that we underestimated the differences between our samples on these variables. A large portion of our income data in both samples was imputed, making it less reliable. It is possible that this unreliability attenuated the association between income and EF skills, and thus the model did not properly adjust for sample differences in income. Furthermore, the coding of parents' occupational status was inexact and based on an old scale that may not be as applicable in the current economy and likely does not perfectly equate occupations in different countries. For example 8% of Chinese children had a parent who was a government employee, with reported salaries ranging from 30,000 to 100,000 yuan. However, because parents' responses were not specific enough to distinguish between low- and high-level government officials, all of these parents received the same occupational status (59, which is equivalent to the score for a human resources officer or salesperson). Furthermore, even low-level government employees likely enjoy higher status in China than in the average Western country. As a result, the scoring may have been inaccurate, resulting in the observed lack of association between occupational status and EF skills. Finally, our American sample included two children with known diagnosed disabilities and may have included more children either whose parents did not report the disability or who had a disability that had not yet been diagnosed. Though we did not collect disability status on individual children in our Chinese sample, it is unlikely that many children with disabilities were in the sample, as these children typically do not attend public kindergartens (see Hu & Szente, 2010b), and only one teacher in our sample reported having any disabled children in her class. The greater presence of children with disabilities in the American relative to the Chinese sample may have led to an overestimation of the culture gap. Ideally, a future study should address these limitations by recruiting a nationally representative sample from both cultures and taking steps to ensure more accurate and complete background data.

Despite these limitations, our estimates of the Chinese culture gap ranged from moderate to large, and as associations between SES and EF tend to be small to moderate (e.g., Noble, McCandliss, & Farah, 2007), these gaps are not likely to be reduced to zero by greater sample equivalence or more accurate socioeconomic data. Additionally, the culture gap still existed for every skill within every subgroup stratified by parental education. Furthermore, our finding that the EF skills of the migrant children in our sample were similar to the average EF skills of our U.S. sample indicate that socioeconomic differences cannot entirely explain the culture gap. Our migrant children were lower than the rest of the Chinese sample on every socioeconomic indicator, and studies consistently find that migrant children are socioeconomically and academically disadvantaged relative to non-migrant urban Chinese children (Hu & Szente, 2010a; Luo et al., 2011). Our U.S. sample was slightly above the national mean on both years of education and household income (U.S. Census Bureau, 2010a, 2011). If the cultural gap were entirely due to unmeasured socioeconomic differences, the American children should have outperformed the Chinese migrant children.

Our results, in combination with those from previous studies, indicate a robust and substantial EF culture gap that emerges as early as age three and persists at least until the end of kindergarten, with attentional control exhibiting the largest discrepancy. As EF skills, particularly attention, have been linked to short-term academic achievement in both cultures (Lan et al., 2011), and to long-term achievement in the U.S. (Duncan et al., 2007), these early EF differences are a likely contributor to the long-standing, persistent, and sizeable gap in both elementary and secondary academic performance (Stevenson et al., 1986; Stevenson, Chen, & Lee, 1993; PISA, 2009). American educators, policymakers, and researchers, in the search for explanations of American children's relatively poor performance and ways to improve it, should examine the reasons behind Chinese children's early advancement in EF development.

Socioeconomic Influences

In line with prior studies (e.g., Noble et al., 2005), we found that parental education was the most consistent socioeconomic predictor of EF skills and growth. Parental education predicted school-entry attention skills in China but not the U.S. and predicted attention growth in kindergarten in the U.S. but not China. This difference could be due to the timing of children's typical entry into a full-time school setting. Because children in China often enter full-time preschool at age three or four, their parents' education may be influencing their attention skills through placement in a high-quality preschool. In contrast, many American children do not begin full-time school until kindergarten, at which time parental education may become important for attention development, again through access to a high-quality school. This result could also be due to differences in Chinese and American parents' expectations of children's attention development. If educated Chinese parents expect children to develop attention skills during the preschool years, they may be placing emphasis on those skills at home, whereas educated American parents may not emphasize attention until kindergarten.

Interestingly, income had an apparent negative association with school-entry attention skills in China and with working memory skills in both countries, though it was a positive predictor of growth in attention and cognitive flexibility. This negative association only appeared after controlling for parental education indicating a suppression effect (Tu, Gunnell, & Gilthorpe, 2008). It is possible that children of parents whose income is higher than expected for their level of education have weaker EF skills at kindergarten entry, but more research would be needed to substantiate this conclusion.

Gender Differences

American educators have become increasingly concerned about boys' academic performance and ability to function in a classroom. Research has confirmed that this concern is well-founded: boys are not achieving at the same level as girls, are more likely to encounter problems in school (i.e., suspensions), and are now less likely to attend college (see Basow, 2010 for a review). Studies with American children have found that boys' school adjustment issues may have their foundations in early differences in EF and self-regulation skills (Duckworth & Seligman, 2006; Howe, 1993). Our results support these conclusions. As predicted, in the U.S., we found a consistent female advantage in kindergarten-entry EF skills, with effect size estimates for attention (0.40) and working memory (0.44) very similar to estimates from prior studies (0.44 for attention, Matthews et al., 2010; and 0.31 to 0.42 for working memory, Lynn & Irwing, 2006). In both cultures, we found a small female advantage in cognitive flexibility (ES = 0.22) but are unaware of any prior studies with young children to which to compare this finding.

However, Chinese children showed no gender gap in kindergarten-entry attention or working memory skills. Scientists have posited that early gender differences in cognitive skills result from the combination and interaction of biological and environmental factors, including prenatal hormone exposure, the timing of brain development, education, parenting, and sociocultural factors (Basow, 2010; Kalhut et al., 2009). Our finding of a cultural difference in gender gaps indicates that environmental factors outweigh biological factors in the determination of EF differences. Either (1) gender differences in EF are more strongly influenced by the environment than by innate biological features or (2) the environment can interact with or overcome the influence of biological features to produce different outcomes. Regardless of the explanation, this finding gives hope to educators striving to intervene early in boys' lives to alter their course of development toward successful academic careers.

The Role of Preschool

Research on early education programs often finds positive impacts on short-term academic and cognitive outcomes (i.e., Berrueta-Clement, Schweinhart, Barnett, Epstein, & Weikart, 1984; U.S. Department of Health and Human Services, 2005). However, many of the studies that advertise large and long-lasting effects are based on high-quality intense programs like the Perry Preschool Project and the Carolina Abecedarian Project, or well-implemented interventions (i.e., Head Start REDI and Chicago School Readiness Project), leaving unclear whether typical American preschool experiences impact the same skills and to the same degree as found in these studies (Fuller, Bridges, & Pai, 2007). In the current study, we expected to find an association between preschool and EF in both cultures, with a stronger association in China. Our hypothesis was only partially supported: preschool was associated with working memory in both cultures, with the same strength of association, but was associated with attention only in China.

A recent study examining preschool effects on EF skills found that attending a typical preschool has a moderate effect on children's working memory ($\eta^2 = 0.14$; Burrage et al., 2008). Similarly, we found that spending more time in preschool had a small association ($\beta = 0.17$) with children's working memory in both the U.S. and China.

Evaluations of preschool interventions have not found working memory differences between intervention and control classrooms (i.e., Bierman et al., 2008b), which may indicate that usual practices in preschool classrooms in the U.S. do a good job of improving working memory.

In contrast, we know of no study that has reported an effect of regular preschool attendance on attention skills, and we did not find an association between preschool attendance and attention in the U.S. We did, however, find a small association (ES = 0.16) between preschool attendance and attention in China. Additionally, the Head Start REDI evaluation found a small intervention effect (ES = 0.28) on children's attention skills (as measured by a task orientation behavioral evaluation; Bierman et al., 2008b). These findings indicate that typical practice in American preschools is not facilitating the development of children's attention skills, but that it is possible for preschool to have an effect on this skill.

The cultural difference observed in our data could be a function of quantity, quality, or both. First, it is possible that the American children in our sample did not spend enough time in preschool in order to see any attention gains, whereas the typical Chinese child in this sample was in full-time preschool for two years. Second, the preschool-attention association in China may be a function of qualitative differences in the environment. Chinese preschools tend to have more teacher-led didactic instruction, which may require more focused attention and enhance the development of this skill (Tobin et al., 2009). Alternatively, if Chinese teachers use more proactive directions than American teachers (as observed by Lan et al., 2006), children may develop greater attention as a result of a need to attend to and remember teachers' instructions. Finally, the Confucian principles guiding Chinese education, which teach persistence and respect for teachers, may lead to children's internalization of the importance of attention, and thus their greater attention development (Li, 2003).

Contrary to McCrea and colleagues' (1999) findings, we did not find an association between preschool and cognitive flexibility (CF). However, these authors investigated these associations in elementary-school children, which may explain the discrepancy. We also did not find, in either culture, that having spent more time in preschool led to greater growth, on average, in any EF skill over the kindergarten year. Our results indicate that preschool benefits are largely immediate, with preschool attendance predicting school-entry skills, and do not appear to carry over into longer-term associations with later skill growth. However, we did find an intriguing combination of interactions in the prediction of CF growth. Gender interacted with both culture and preschool, such that in both cultures, girls were predicted to show less CF growth in kindergarten if they had spent more time in preschool, though the effect was larger in the American sample. This finding does not appear to reflect a catch-up effect, as preschool attendance had no association with school-entry CF skills. Boys, on the other hand, were predicted to have slightly greater CF growth with more time in preschool. This unexpected outcome may be due to the particular task used to assess CF in this study. At both time points, approximately half of children were able to do the first phase of the task perfectly, but completely unable to do the second phase of the task, resulting in children being stuck at the same score. This task has since been revised to include an intermediate phase, resulting in scores that reflect more continuous development. This finding may be the result of a problematic assessment and should be replicated before any practical conclusions are drawn.

The Composition of Executive Functioning in Early Childhood

The results of this study showed different culture gaps, gender gaps, and preschool associations depending on the skill tested, indicating that working memory, attentional control, and cognitive flexibility are separable skills in young children. Furthermore, the particular pattern of findings hints at a specific developmental progression. The Chinese children were advanced in all three skills, but their attention advantage appeared to have stabilized by the beginning of kindergarten; in contrast, the working memory and cognitive flexibility gaps grew over the kindergarten year. Additionally, though a gender gap existed for American children in all three skills, a gender gap for Chinese children was only present in cognitive flexibility. These findings indicate that Chinese children have mastered the basics of attention by the beginning of kindergarten, and that cognitive flexibility may be the only of these skills with which they are still struggling at age five.

These results point to a possible developmental order for the development of these skills: first attentional control, followed by working memory, then cognitive flexibility. This ordering matches the observed difficulty of the tasks in the American sample: 97% of children could complete the attention task, whereas only 70% could do the working memory assessment and only 24% could do the advanced version of the cognitive flexibility task. This developmental path aligns with Miyake and Friedman's (2012) recent theory which suggests that EF is made up of one common underlying skill, which includes inhibition (closely related to attentional control), and two separate specific skills:

working memory and cognitive flexibility. Within this framework, it is reasonable to assume that children would first develop the common EF skill (here assessed by the attentional control task) and then develop the more specific working memory and cognitive flexibility skills. However, more research is needed to clarify this developmental pathway.

Limitations and Future Directions

Our results should be interpreted with caution because they are correlational in nature, and we have no measure of children's skills before entering preschool. Our Chinese children were mostly sampled from public preschools in Beijing, and children in these preschools may be advantaged relative to the general population of urban Chinese children. In contrast, our American sample was recruited through public kindergarten classrooms in diverse districts, the majority of which serve substantial numbers of low-income children, and thus are likely not an elite group. Though we controlled for socioeconomic differences, there may be other factors, such as parents' motivation, that influenced both the children's enrollment in preschool and their executive functioning. Furthermore, in some cases children may have been admitted to preschools because they displayed cognitive advancements, as anecdotal reports indicate that some schools require children to attend pre-admission classes with parents or pass assessments before enrolling (Liu, 2012; Song, 2012). Conversely, because we had relatively few Chinese children who did not spend substantial time in preschool, it is also possible that our study underestimated the effect of preschool in China.

A future study should follow children prospectively through preschool in both countries to verify and clarify these findings, and to attempt to identify which facets of

Chinese preschool practices may be facilitating the development of attention. The Chinese system is far from perfect, but in high-quality programs, teachers may be engaging in attention-promoting practices that American teachers are not. China has also set an ambitious plan for the expansion of pre-primary programs with the goal of 80% of four-year-olds and 70% of three-year olds-enrolled in preschool by 2020 (Li, 2012). Our results, in combination with the vast literature on the positive effects of early education, indicate that the U.S. would be wise to follow China's lead in expanding access to public preschool.

Table 1.1

Participants' Ethnic Backgrounds (Study 1)

	Chinese	
Ethnicity	Number	Percentage
Han	170	86.7
Hui	10	5.1
Mongolian	5	2.6
Man	5	2.6
Korean	3	1.5
Unreported	3	1.5
	American	
Caucasian	114	57.6
African American	10	5.1
Hispanic	6	3.0
Asian	2	1.0
Arabic	9	4.5
Native American	2	1.0
Multiracial	5	2.5
Unreported	50	25.3

Table 1.2

Demographics (Study 1)

	Chinese			
	Mean	SD	Range	*N*
Child's Age at K Entry *(months)*	64.9*	4.2	53 – 75	196
Maternal Age *(years)*	35.3	4.2	25 – 49	190
Paternal Age *(years)*	38.1	4.9	25 – 58	189
Household Income *(yuan)*	115,794*^	89,869	0 – 560,000	143
Parental Education *(years)*				
Maternal Education	14.4	3.2+	6 – 21	187
Paternal Education	14.7*	3.1+	6 – 21	186
Higher of Both Parents	15.1	3.2	6 – 21	190
Occupational Status				
Mother's ISEI Score	59.7*	14.0	24 – 88	157
Father's ISEI Score	59.6*	14.7	24 – 90	152
Higher of Both Parents	63.8*	13.6	24 – 90	170
	American			
Child's Age at K Entry *(months)*	63.5	3.8	57 – 75	198
Maternal Age *(years)*	35.2	5.7+	23 – 52	127
Paternal Age *(years)*	37.2	6.4+	24 – 58	120
Household Income *(dollars)*	61,258	46,062	0 – 191,000	105
Parental Education *(years)*				
Maternal Education	14.3	2.6	6 – 19	147
Paternal Education	13.7	2.3	6 – 19	139
Higher of Both Parents	14.8	2.5	7 – 19	149
Occupational Status				
Mother's ISEI Score	51.7	15.9	24 – 88	101
Father's ISEI Score	49.9	16.2	10 – 88	109
Higher of Both Parents	54.3	15.8+	24 – 88	134

Note. * Indicates that the mean is higher for this culture as compared to the other.
+ Indicates that the variance is higher for this culture as compared to the other.
^ The mean comparison for household income was calculated using the transformed data; see *Measures* section.

Table 1.3

Educational Experiences and Corresponding Years of Education Estimate

Educational Experience	Years of Education
Completed elementary school	6
Completed middle school	9
Graduated from high school or earned equivalency degree	12
Some college courses	13
Two-year college degree	14
Four-year college degree	16
Some graduate school	17
Master’s degree	18
Professional degree (i.e., M.D. or J.D.)	19
Doctoral degree	21

Note. Some parents who did not complete high school listed the last grade they completed, in which case they were assigned a value equal to that grade (i.e., if a parent listed 10^{th} as the last grade completed, that parent was assigned a value of 10).

Table 1.4

Rates of Missingness for Key Variables (Study 1)

	U.S.	China
Household Income	60%	28%
Parental Education (Higher of Both Parents)	31%	7%
Occupational Status (Higher of Both Parents)	44%	16%
Total Preschool Hours	48%	9%
Fall Attention	2%	0%
Fall Working Memory	28%	2%
Fall Cognitive Flexibility	0.5%	0.5%
Spring Attention	3%	9%
Spring Working Memory	7%	9%
Spring Cognitive Flexibility	3%	9%

Table 1.5

Indicators of Preschool Attendance

	Chinese			
	Mean	SD	Range	*N*
Attendance Rate	99%*	---	---	184
Total Months Attended	21.4*	4.6	0 – 30	180
Hours/Week	43.7*	5.2	0 – 50	183
Total Estimated Hours	4,161.2*	902.4	---	---
	American			
Attendance Rate	95%	---	---	146
Total Months Attended	15.5	7.4	0 – 31	134
Hours/Week	16.1	11.5	0 – 45	109
Total Estimated Hours	1378.5	1237.5	---	---

Note. * Indicates that the mean is higher for this culture as compared to the other. The means for Total Estimated Hours were calculated using the imputed data.

Table 1.6

EF Skills at Kindergarten Entry and Exit by Culture

Fall of Kindergarten									
	Attention			Working Memory			Cognitive Flexibility		
	Mean	SD	Z-Score	Mean	SD	Z-Score	Mean	SD	Z-Score
U.S.	17.15	7.29	-0.42	7.76	4.86	-0.30	5.73	2.52	-0.28
China	23.55	6.59	0.42	11.05	5.29	0.30	7.10	2.25	0.28
Spring of Kindergarten									
	Attention			Working Memory			Cognitive Flexibility		
	Mean	SD	Z-Score	Mean	SD	Z-Score	Mean	SD	Z-Score
U.S.	24.97	8.68	0.61	11.17	4.78	.32	6.67	2.64	.11
China	32.49	6.58	1.59	16.79	6.57	1.37	8.73	2.49	.94

Note. Z-scores were created by standardizing scores using the fall mean and standard deviation of the full sample for each assessment.

Table 1.7

Correlations among EF Scores

	1	2	3	4	5	6
1. Fall Attention	---	.26	.22	.43	.28	.31
2. Fall WM	.29	---	.33	.21	.61	.45
3. Fall CF	.23	.26	---	.23	.23	.46
4. Spring Attention	.37	.16	.17	---	.23	.13
5. Spring WM	.29	.48	.30	.35	---	.53
6. Spring CF	.23	.28	.37	.19	.34	---

Note: Correlations in the American sample are below the diagonal; correlations for the Chinese sample are above the diagonal.

Table 1.8

Intraclass Correlations of Fall and Spring EF Scores

Fall Scores			
	Attention	WM	CF
Fully Unconditional Model	.23**	.24**	.14**
Model Controlling for Culture	.07**	.17**	.07**
Spring Scores			
Model Controlling for Fall Score	.11**	.35**	.15**
Model Controlling for Culture & F. Sc.	.03+	.25**	.07**

Note. * p<.05; **p<.01. Stars indicate the significance of the between-classroom variance.

Table 1.9

Culture Gap in EF Skills at Kindergarten Entry

	Attention		Working Memory		Cognitive Flexibility	
	Est.	St. Err.	Est.	St. Err.	Est.	St. Err.
Intercept	-0.38**	0.08	-0.28**	0.10	-0.26**	0.07
Age	0.19**	0.05	0.13**	0.04	0.12*	0.05
Culture (China=1)	0.79**	0.11	0.59**	0.16	0.54**	0.12
ICC of resid.var.	.05*		0.16**		.06**	

Note. * p<.05; **p<.01. Stars in the ICC row indicate the significance of the between-classroom residual variance. Culture was entered uncentered, so the intercept represents the U.S. Age was standardized in the full sample.

Table 1.10

Culture Gap in EF Skills at Kindergarten Entry, Controlling for Family Background

	Attention		Working Memory		Cognitive Flexibility	
	Est.	St. Err.	Est.	St. Err.	Est.	St. Err.
Intercept	-0.39^{**}	0.06	-0.33^{**}	0.10	-0.21^{**}	0.08
Age	0.19^{**}	0.05	0.11^{*}	0.04	0.11^{*}	0.05
Parental Education	0.15^{*}	0.07	0.24^{**}	0.06	0.17^{**}	0.07
Parental Occupation	-0.11	0.07	0.002	0.07	-0.01	0.07
Household Income	0.04	0.07	-0.17	0.07	0.10	0.06
Culture (China=1)	0.80^{**}	0.10	0.62^{**}	0.15	0.47^{**}	0.12
ICC of residual var.	.03		$.15^{**}$		$.03^{+}$	

Note. +p<.10, * p<.05, **p<.01. Stars in the ICC row indicate the significance of the between-classroom residual variance. Culture was entered uncentered, so the intercept represents the U.S. Household income was left in the original transformed metric so that zero represents average household income in one's country, and all other continuous variables were standardized in the full sample.

Table 1.11

Culture Gap in EF Growth in Kindergarten, Controlling for Family Background

	Attention		Working Memory		Cognitive Flexibility	
	Est.	St. Err.	Est.	St. Err.	Est.	St. Err.
Intercept	0.87**	0.07	0.53**	0.09	0.29**	0.07
Culture (China=1)	0.49**	0.11	0.61**	0.16	0.54**	0.11
Age	0.14*	0.05	0.05	0.04	0.02	0.04
Parental Education	0.12+	0.07	0.17*	0.06	0.21**	0.06
Parental Occupation	-0.01	0.08	-0.05	0.06	-0.08	0.07
Household Income	0.13*	0.05	-0.04	0.08	0.13	0.09
Fall Score	0.38**	0.05	0.55**	0.05	0.36**	0.05
Time b/t Tests	0.09+	0.05	0.19*	0.07	0.05	0.06
ICC of residual var.	.01		.18**		.04+	

Note. +p<.10, * p<.05, **p<.01. Stars in the ICC row indicate the significance of the between-classroom residual variance. Fall Score refers to the child's fall score on the respective skill. Culture was entered uncentered, so the intercept represents the U.S. Household income was left in the original transformed metric so that zero represents average household income in one's country, and all other continuous variables were standardized in the full sample.

Table 1.12

EF Skills at Kindergarten Entry and Exit by Culture and Parental Education

			Fall of Kindergarten								
	N_{US}	$N_{Ch.}$	Attention			Working Memory			Cognitive Flex.		
			U.S.	China	Gap	U.S.	China	Gap	U.S.	China	Gap
Full Sample	*198*	*196*	17.15	23.55	6.4	7.76	11.05	3.29	5.73	7.10	1.37
Migrant Children	---	*21*	---	18.48	1.33	---	7.06	-0.70	---	5.57	-0.16
Less than H.S.	*10*	*16*	13.00	17.81	4.81	---	5.73	---	2.80	5.47	2.67
H.S. or Assc. Degree	*79*	*60*	17.65	23.05	5.4	---	11.12	---	5.57	6.90	1.33
College Degree	*34*	*60*	17.38	24.42	7.04	---	11.85	---	6.65	7.37	0.72
Graduate Degree	*36*	*54*	18.94	24.76	5.82	---	12.13	---	6.31	7.44	1.13
			Spring of Kindergarten								
Full Sample	*198*	*196*	24.97	32.49	7.52	11.17	16.79	5.62	6.67	8.73	2.06
Migrant Children	---	*21*	---	28.81	3.84	---	9.83	-1.34	---	6.50	-0.17
Less than H.S.	*9*	*13*	15.56	26.77	11.21	---	9.69	---	5.56	6.31	0.75
H.S. or Assc. Degree	*79*	*55*	24.00	31.96	7.96	11.14	16.82	5.68	6.51	8.22	1.71
College Degree	*34*	*56*	23.97	33.41	9.44	12.16	18.07	5.91	6.97	9.20	2.23
Graduate Degree	*36*	*52*	29.42	34.06	4.64	12.97	18.62	5.65	7.97	9.83	1.86

Note. Means for the full sample and the migrant children were calculated using imputed data. Subgroup means are based only on those children whose parents reported their educational level and who had assessment data (as a result, the total number of participants in the subgroups is less than the number of participants in the full sample). Because of high rates of non-randomly missing data in the U.S., no subgroup mean is reported for the fall working memory assessment, and the "less than high school" group mean is not reported for the spring working memory assessment. Gaps were calculated by subtracting the U.S. mean from the Chinese mean, so a positive number indicates a Chinese advantage. Gaps reported in the "Migrant Children" rows compare the migrant children's means to the full U.S. sample's means.

Table 1.13

Gender and Preschool Associations with Kindergarten-Entry EF Skills in the U.S. and China

	United States					
	Attention		Working Memory		Cognitive Flexibility	
	Est.	St. Err.	Est.	St. Err.	Est.	St. Err.
Intercept	-0.30*	0.11	-0.22^{+}	0.11	-0.15	0.10
Culture (China=1)	0.49*	0.19	0.41*	0.19	0.38^{+}	0.06
Migrant (Yes=1)	-0.36*	0.17	-0.58**	0.18	-0.14	0.15
Age	0.23**	0.07	0.07^{+}	0.04	0.19**	0.07
Age x Culture	-0.17^{+}	0.10	---	---	-0.18*	0.09
Parental Education	-0.03	0.11	0.21**	0.06	0.16**	0.06
Par. Ed. x Culture	0.22^{+}	0.12	---	---	---	---
Household Income	0.13	0.10	-0.17*	0.07	0.10	0.06
Income x Culture	-0.27*	0.11	---	---	---	---
Gender (Male=1)	-0.40**	0.12	-0.44**	0.13	-0.22**	0.08
Gender x Culture	0.48**	0.15	0.30^{+}	0.18	---	---
Preschool Hours	0.04	0.11	0.17*	0.08	0.06	0.11
Preschool x Culture	0.27^{+}	0.16	---	---	---	---
ICC of residual var.	.03		.15**		.04*	

Note. +p<.10;* p<.05; **p<.01. (---) indicates that the variable was not included in the model for that outcome. Stars in the ICC row indicate indicate the significance of the between-classroom residual variance. Gender and Migrant were entered grand-mean centered, and Culture was entered uncentered, so the intercept represents children in the U.S. Household income was left in the original transformed metric so that zero represents average household income in one's country, and all other continuous variables were standardized in the full sample.

Table 1.14

Gender and Preschool Associations with EF Growth in Kindergarten in the U.S. and China

	United States					
	Attention		Working Memory		Cognitive Flexibility	
	Est.	St. Err.	Est.	St. Err.	Est.	St. Err.
Intercept	0.85^{**}	0.11	0.57^{**}	0.13	0.51^{**}	0.10
Culture (China=1)	0.55^{*}	0.21	0.52^{+}	0.26	0.09	0.18
Migrant (Yes=1)	0.28	0.17	-0.56^{*}	0.22	0.21	0.22
Fall Attention	0.38^{**}	0.05	0.13^{**}	0.05	0.11^{*}	0.04
Fall WM	0.09^{*}	0.04	0.49^{**}	0.05	0.27^{**}	0.06
Fall CF	---	---	0.10^{+}	0.05	0.27^{**}	0.06
Time b/t Tests	0.11^{*}	0.05	0.18^{*}	0.07	0.08	0.05
Age	0.16^{**}	0.06	0.02	0.05	-0.03	0.05
Age x Culture	---	---	---	---	---	---
Parental Education	0.25^{*}	0.10	0.13^{*}	0.06	0.11^{+}	0.05
Par. Ed. x Culture	-0.22^{*}	0.11	---	---	---	---
Household Income	0.16^{**}	0.05	-0.08	0.08	0.19^{+}	0.08
Income x Culture	---	---	---	---	---	---
Gender (Male=1)	-0.10	0.09	0.04	0.09	0.33^{+}	0.17
Gender x Culture	---	---	---	---	-0.80^{*}	0.33
Preschool Hours	-0.11	0.12	0.02	0.11	-0.12	0.12
Preschool x Cul.	---	---	---	---	---	---
Preschool x Gend.	---	---	---	---	0.46^{**}	0.17
ICC of resid.var.	.02		$.19^{**}$		.02	

Note. +p<.10;* p<.05; **p<.01. (---) indicates that the variable was not included in the model for that outcome. Stars in the ICC row indicate indicate the significance of the between-classroom residual variance. Gender and Migrant were entered grand-mean centered, and Culture was entered uncentered, so the intercept represents children in the U.S. Household income was left in the original transformed metric so that zero represents average household income in one's country, and all other continuous variables were standardized in the full sample.

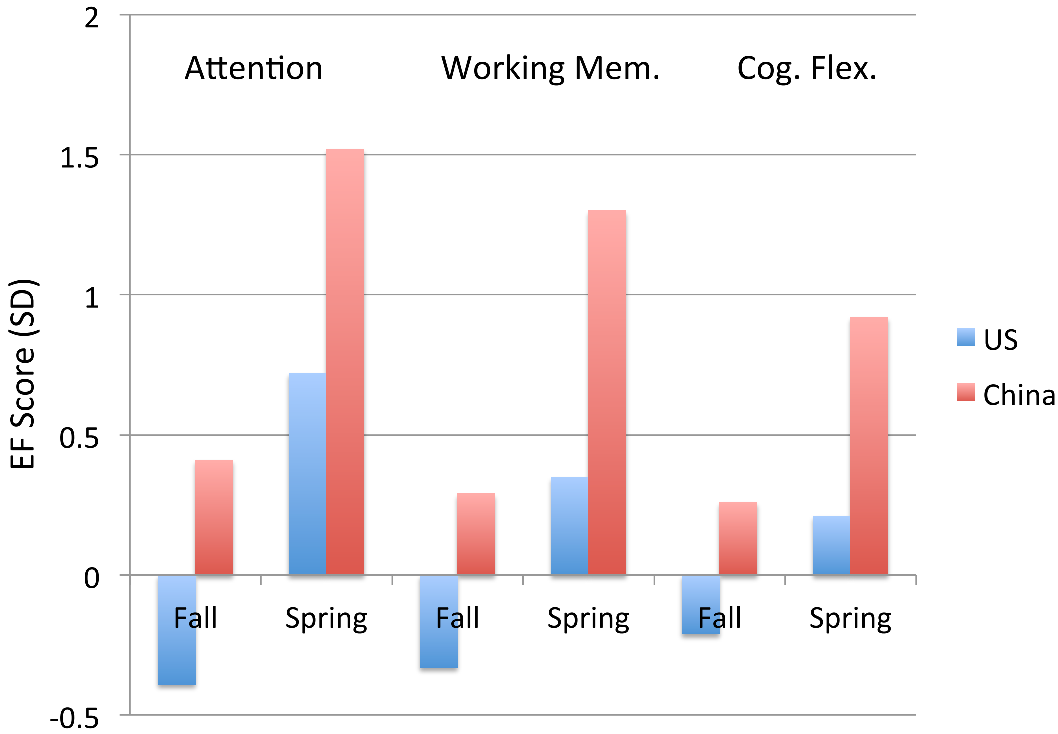

Figure 1.1. Culture Gaps in Fall and Spring EF Scores. Predicted spring scores were calculated using the mean pretest score for each culture, holding all other variables constant at the sample mean.

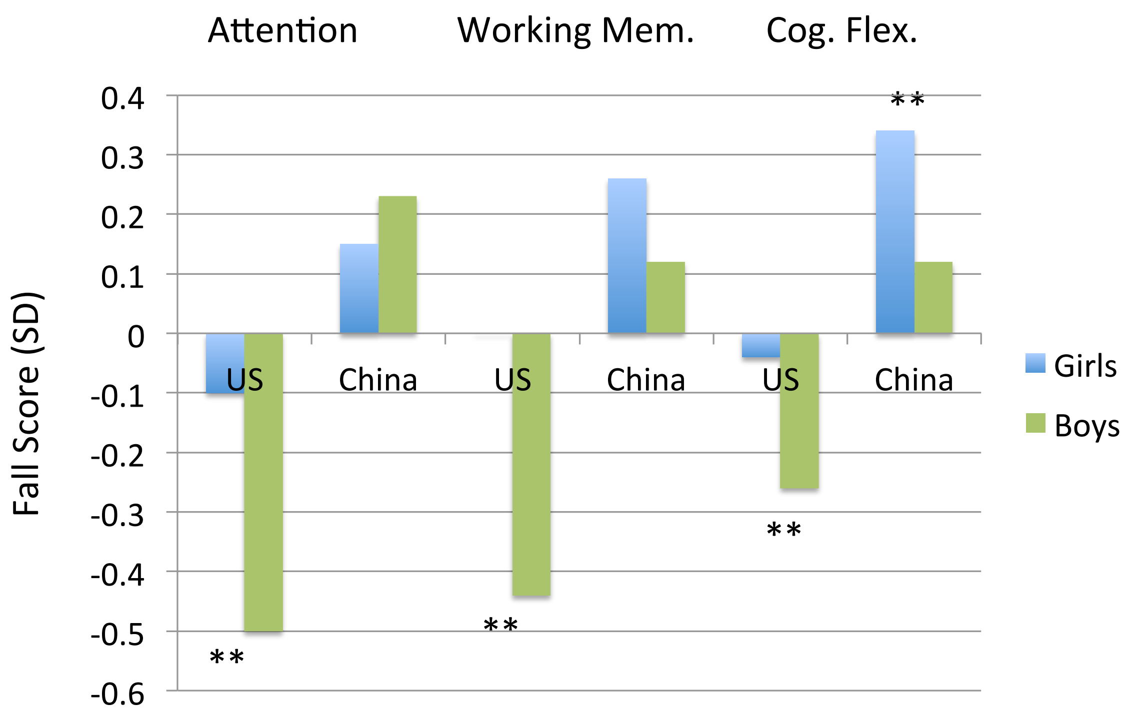

Figure 1.2. Gender Gaps in Kindergarten-Entry EF Skills in the U.S. and China.
** indicates a significant gender difference.

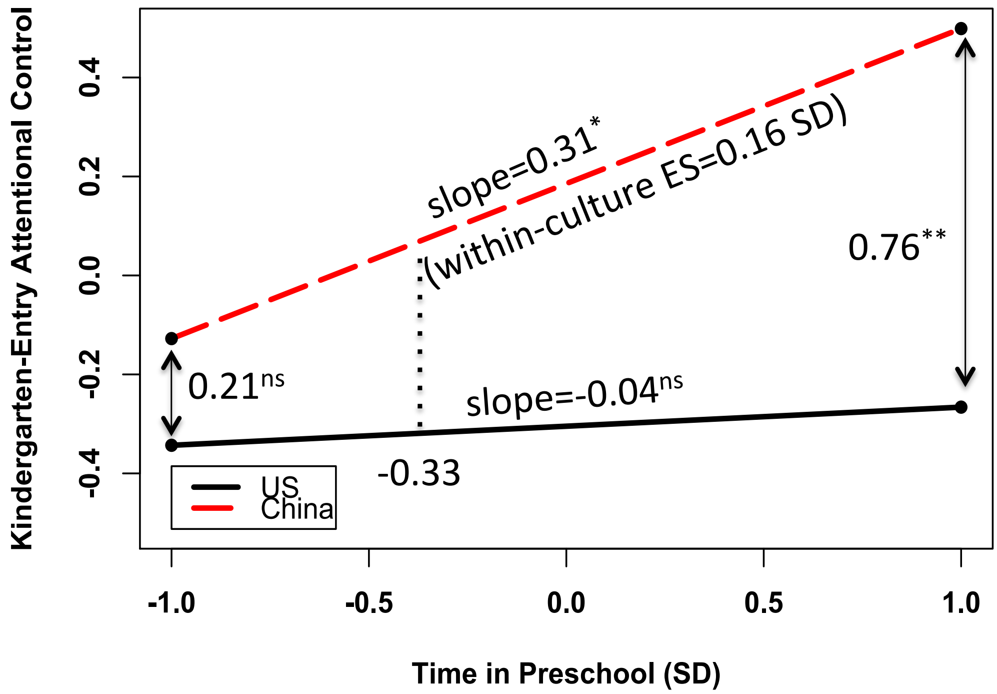

Figure 1.3. Time in Preschool Predicts Kindergarten-Entry Attention in China. The within-culture effect size was calculated using the SD for preschool attendance in China, which is about half the SD for preschool attendance in the full sample. The culture gap in attention skills is significant when time in preschool is greater than 0.33 SD below the mean. The culture gap is not significant at low levels of preschool time, but low levels of preschool were rare in the Chinese sample.

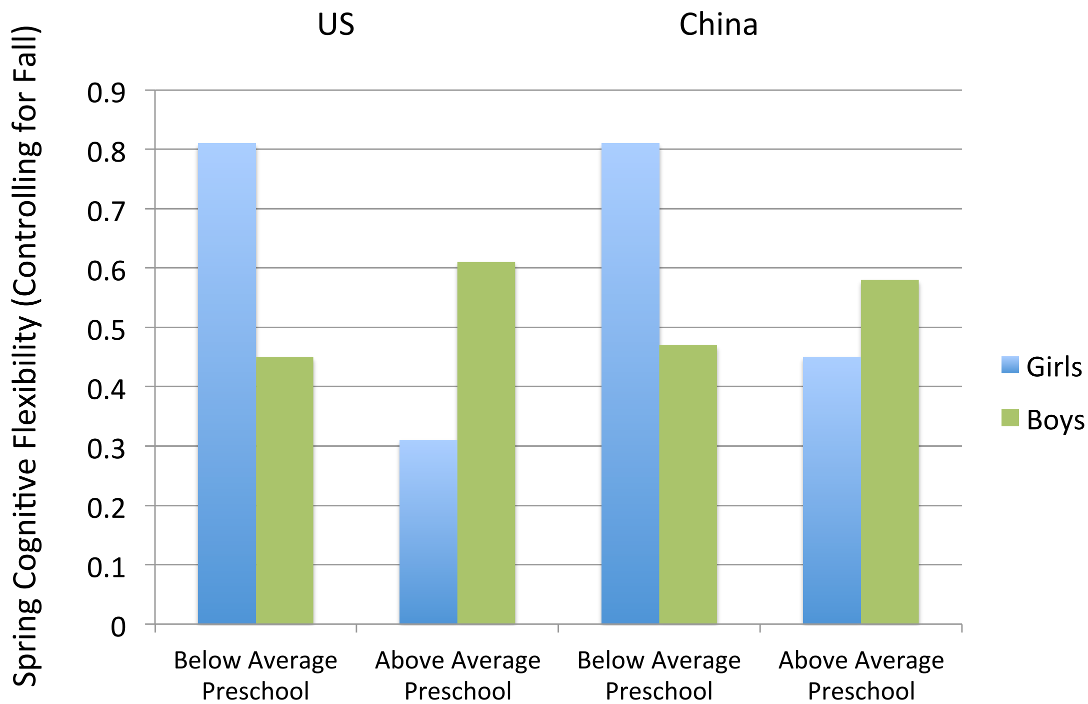

Figure 1.4. Differences in Spring Cognitive Flexibility by Culture, Gender, and Preschool Attendance. “Below Average” and “Above Average” refer to 1 SD below and above the respective culture’s means. Predicted scores were calculated using the average pretest score in each culture, holding all other variables constant at the sample mean.

Chapter III

Study 2: Associations between Classroom Activities and EF Growth

Psychologists, educators, and policymakers have long debated the characteristics of the “best” classroom environment for young children. Advocates of a child-centered, play-based approach argue that direct instruction is inappropriate for young children, and that learning should happen through child-driven discovery-based activities (i.e., Bredekamp, 1987). At the other end of the spectrum, proponents of direct instruction contend that children need instruction in basic skills in order to succeed in elementary school (Graue, 1999). However, researchers have not found conclusive evidence that one approach is definitely “better” than the other or produces better-prepared students, and fully adopting one approach while ignoring the other can lead to pitfalls like teachers who take no responsibility for students’ learning, in the child-centered case, or students who are not active participants in their own learning, in the direct instruction case (Graue, 1999; Klahr & Nigam, 2004). Recent research on effective classrooms and instruction highlights the importance not of the curriculum or theoretical approach, but of the teacher’s creation of effective lessons through awareness of students’ prior knowledge, engaging presentation of content, encouragement of students’ active participation, provision of informative feedback, and appropriate structuring and organization of the classroom, among others (Carlisle, Kelcey, Berebitsky, & Phelps, 2011; Patrick, Mantzicopoulos, & Sears, 2012).

American classrooms vary widely in the experiences that they provide to children (Hamre & Pianta, 2007), leading to differential academic and cognitive growth among classrooms. Unsurprisingly, studies find that children show greater academic achievement in classrooms that spend more time in academic activities (i.e., Greenwood, 1991). Recent research also indicates that academic instruction may influence the development of basic cognitive skills. Researchers have consistently found that EF skills have a stronger connection to mathematics than to other academic outcomes (e.g., Duncan et al., 2007; Matthews et al., 2009). Though this finding is typically interpreted as showing that EF influences math learning, the direction of causality may be the reverse: learning mathematics may influence the development of EF skills. A recent analysis of classroom data supports this interpretation: Bell and Morrison (2011, April) found that in kindergarten classrooms, the time that children spent engaged in mathematics-comprehension activities predicted their inhibition skill growth over the kindergarten year. Additionally, a study of 60 preschool classrooms found a similar association between mathematics instruction and gains on an aggregate EF measure, as well as an association between time spent in teacher-managed instruction and EF growth (Fuhs, Farran, Meador, & Norvell, 2012, June).

Instructional content and time are not the only salient features of the classroom. Non-instructional factors, such as classroom management and organization, are important for both classroom functioning and children's skill development. For example, teachers who establish procedures at the beginning of the year and clearly communicate behavioral expectations to students create more successful environments (Evertson & Harris, 1992). Results from one study showed that teachers who devoted more time in the fall to explaining procedures to children and organizing activities had better functioning classrooms, as measured by less time spent in transitions and more time spent in child-managed activities (Cameron, Connor, and Morrison, 2005). Additionally, qualitative studies have found that teachers whose students showed greater academic growth devoted more time at the beginning of the year to teaching rules and procedures (Bohn, Roehrig, & Pressley, 2004; Pressley et al., 2001). Quantitative studies have also shown that more time spent orienting children to activities and procedures led to greater literacy skill growth in first grade (Cameron, Connor, Morrison, & Jewkes, 2008; Ponitz, Rimm-Kaufman, Brock, & Nathanson, 2009) and greater literacy, mathematics, and inhibition growth in preschool (ES = 0.24 for inhibition; Cameron & Morrison, 2011).

The findings discussed above point to the clear importance of both instructional and non-instructional aspects of the classroom environment. In particular, time spent in academic activities and in orienting children to classroom procedures have been identified as influential for both classroom functioning and children's academic achievement. However, few studies have examined associations between these components of the classroom and children's EF development. Because academic activities place demands on children's executive systems by requiring, for example, attention to the task, memory of information and instructions, and the inhibition of distractions, spending time engaged in these activities may influence the development of multiple EF skills. Additionally, because orienting minimizes wasted classroom time (Cameron et al., 2005) and as Cameron and Morrison (2011) argue, enhances children's ability to conduct and complete tasks, more orientation should also relate to children's EF development as a result of their increased opportunities for and effective engagement with academic activities.

The Current Study

The current study explores associations among time spent in academic activities, time spent in orientation, and EF skill growth over the kindergarten year. Based on prior findings, we anticipate that both activity types will contribute to children's EF development in the U.S. However, because prior studies have been conducted in Western schools, it is unclear whether these associations will emerge in Chinese classrooms. Orientation may be less predictive of EF development in China than it is in the U.S. Because most Chinese children in this sample have been in the same school for two years prior to the beginning of the kindergarten year, they may already be used to the typical classroom routines and activities, and as a result, may not need or benefit from more time in orientation. Additionally, because the academic content in American and Chinese kindergarten classes is likely to differ, academic activities may have a stronger influence on EF skills in one culture or may predict growth in different skills in the two cultures.

Research Questions

1. Does time spent in orientation predict children's growth in EF over the kindergarten year, and are the associations consistent across skills and cultures?
    a. Hypothesis 1: Orientation will be associated with growth in attentional control and may be associated with growth in other skills in both cultures.
2. Does time spent in academic activities predict children's growth in EF over the kindergarten year, and are the associations consistent across skills and cultures?
    a. Hypothesis 2a: Academic activities will be associated with growth in all

EF skills, though the strength of association may vary by skill.

b. Hypothesis 2b: Because American kindergarten instruction primarily focuses on literacy skills, and Chinese instruction tends to be more varied, academic activities may have differential influences on EF growth in the U.S. and China.

Method

Participants

Children.

This study utilized the same participants from Study 1 and included the five American children who were repeating kindergarten, for a total of 203 American and 196 Chinese children (see Tables 2.1 and 2.2 for demographic information). In China, 17 students were not available for the spring assessments because their families had moved to a different school district (n = 7) or because their parents were migrant workers who had left the area (n = 10). In the U.S., seven students were not available for the spring assessments because they had moved to a different district. However, because multiple imputation was used to recover missing data, the full sample was retained.

Teachers and classrooms.

In both cultures, we attempted to include a diverse sample of schools but were limited by time and resources. As a result, the schools are a convenience sample drawn from districts in which researchers had contacts and which were open to participating in the study. Fourteen teachers in China (from 8 schools in 5 districts) and 19 teachers in the U.S. (from 10 schools in 6 districts) participated in the study. Chinese classrooms had between 9 and 21 participating children per class. In the U.S., two teachers had both a morning and an afternoon class, making a total of 21 classrooms with between 5 and 13 participating children per class. American teachers were all female and Caucasian and had an average of 8.4 years of teaching experience. All held a college degree, and 43% held a master's degree. One teacher reported having a part-time co-teacher, and 16 reported having at least one aide, intern, or inclusion teacher, though most were present for only a few hours per week. Classrooms had an average of 24 students (13 boys), 2 second-language-learners, and 2 students with disabilities or developmental delays. Sixty-seven percent of classrooms were in a Title I school, and five classes were half-day.

In China, teachers were all female and of Han ethnicity and had an average of 10.6 years of teaching experience. One teacher had only a high school diploma, three had associate's degrees, and ten held bachelor's degrees. With the exception of the migrant-school teacher, all Chinese teachers reported having between one and three full-time co-teachers. Classrooms had an average of 36 students (20 boys), no second-language learners, and with the exception of one teacher that reported having two students with disabilities, no students with disabilities or developmental delays.

All Chinese classrooms, with the exception of one, were in public kindergartens. In Beijing, children attend the same school (called kindergarten) from age 3 to age 6, and then enter primary school. To parallel the terminology used in the U.S., we refer to the year of schooling that we observed as "kindergarten," but in China, it is called "big kindergarten," because it is the last year of kindergarten. One classroom was in a special school set up for the children of migrants who are not legal residents of Beijing. These schools are funded by private donations and tuition rather than public funds. The class we observed in this school was for children of kindergarten age (5 – 6).

Procedure

Children were assessed during the first two months of kindergarten and again during the last two months in mathematics, literacy, and EF skills (refer to the *Measures* section of Study 1 for descriptions of the assessments). At the time of the fall assessments, researchers also videotaped classrooms for the first academic hour of a typical school day. In the U.S., observations took place between mid-September and mid-November; in China, observations took place between mid-September and late October. Because all American classrooms began the day with academic activities, observations began at the beginning of the school day. In China, many classrooms began the day with free play, so observations began at the time the teacher designated as the beginning of instructional time. Observations were designed to last for one hour, but due to practical constraints, actual observation time ranged from 36 minutes to 1 hour 21 minutes, with a mean of one hour.

These videos were analyzed using Noldus Observer XT software. Additionally, teachers completed self-administered questionnaires, reporting information about their background, the makeup of their classroom, and the way that children typically spent their class time. Parents completed a self-administered questionnaire covering the family's demographic information, their educational background and occupations, and their child's childcare and preschool history (see Study 1 *Measures* section).

Observation Coding

Coding was conducted by one English-speaker researcher and one English-Mandarin bilingual researcher. The researchers coded seven American videos (33% of the U.S. sample; 20% of the total sample) to establish reliability. They first coded four training videos together, discussing and recoding until they agreed on the codes. They then coded three test videos separately. The average Cohen's kappa value for these videos was .74 (.67, .73, and .82).

For the duration of the observation, classroom activities were coded continuously into five mutually exclusive categories: academic instruction, orientation, free play, transition between activities, and ritual (i.e., taking attendance). These codes were assigned based on what the majority of the class was doing at the time. The current study focused on two activities: academic instruction and orientation. Academic instruction included all activities with an instructional focus. This instruction was coded into six sub-categories: language arts, mathematics, science/social studies, art/music, practical life (i.e., hygiene, basic knowledge such as colors), and other (coded when either the activity did not fall into one of the categories, for example, a motor skills game, or when children were doing a variety of instructional activities from different categories). Orientation was coded when the teacher provided information about an upcoming activity, general classroom functioning, or how children were expected to behave in a situation. For each code, the total duration of the activity was divided by the observation duration to create a percentage of the observed class time spent in that activity.

Results

Missing Data

In China, 98% of families returned their questionnaires, but in the U.S., only 76% of families did. This imperfect return rate, in combination with individual item non-responses, resulted in missing data rates of up to 60% for some background variables. Additionally, in the fall, more than a quarter of the American children were not able to understand the instructions of the working memory task, and thus were not able to complete the assessment. Finally, seven American children and 17 Chinese children were not available for the spring assessments (see Table 2.3).

As in Study 1, multiple imputation was used to handle missing data. Multiple imputation uses an iterative Bayesian procedure to create multiple copies of the data, each with different plausible values (based on the associations among the variables) for the missing observations. Results are then averaged over these datasets to create the best estimate of each parameter, and standard errors are adjusted for the additional uncertainty due to missing data (Enders, 2010). In this study, we had the same concerns expressed in Study 1 about meeting the Missing at Random assumption, but again because of the inclusive analysis strategy used (see description below), any bias is likely to be minimal (Enders, 2010).

Imputations were conducted separately for the American and Chinese data in order to maintain the separate covariance structures within the cultures. All analysis variables were included in the imputation. In addition, mothers' and fathers' individual incomes were included, as some questionnaires contained only one parent's income. The individual components used to create the preschool attendance variable were also included, as some parents indicated that the child had attended preschool, but gave no further information, or listed the months of attendance but not the hours per week. Finally, four additional fully observed auxiliary variables (children's math scores and teachers' ratings of children's self-regulation, working memory, and motivation) were included to improve the prediction of missing EF scores. The imputation models were identical in both cultures with two exceptions: because migrant status was used as a control in the analysis of Chinese data, it was included in the imputation for that culture. Also, in China, months of preschool was almost perfectly correlated with total hours of preschool, so preschool months was removed to avoid non-convergence due to multicollinearity.

The imputation was done with a two-level model to account for the nesting of children in classrooms. Most variables were allowed to have both within- and between-classroom variance. However, gender and migrant status were restricted to the within-classroom level, because in this model, the estimator could not accommodate a dichotomous variable with variance at both levels. Age was also limited to the within level because it had almost no classroom-level variance. Academic instruction and orientation were restricted to the between level, as they were observed at the class level and had no within-class variance.

All variables were allowed to correlate with each other at the within level. However, because of the small number of classrooms and thus the limited degrees of freedom at the class level, the between model was more restrictive. Between-level variance was estimated for all variables (except gender, migrant, and age), but only associations that were tested in the analysis model were specified at the between level: spring EF scores were regressed on fall EF scores, academic instruction, and orientation.

The imputation was conducted in Mplus version 6.1 with 100,000 iterations of the Gibbs sampler algorithm using two Markov chains with uninformative prior distributions (Muthén & Muthén, 2010). Time-series plots of variables with high rates of missingness were examined to verify that parameter estimates had reached a stable pattern and exhibited minimal autocorrelation (Enders, 2010). Ten imputed data sets, each separated by 200 iterations, were used for analysis.

Classroom Activities

T-tests were used to identify differences in total duration times and in time spent in various activities in Chinese and American classrooms (all classrooms had complete observational data with no missing values). Observations were longer, on average, in American classrooms (1 hour and 5 minutes vs. 52 minutes; $t_{(30.72)} = 4.72$, $p < .001$). Both Chinese and American classrooms spent an average of 10% of observed time in orientation, with observed values ranging between zero and 30%. American classrooms spent a larger portion of time in activities coded as "ritual" (18% vs. 4%; $t_{(33)} = 4.4$, $p < .001$; see Table 2.4), because most American kindergarten classes began the day with announcements, sharing, the Pledge of Allegiance, and other routine non-instructional activities that were not a typical part of the Chinese school day. However, Chinese classrooms spent a larger portion of time in academic activities (59%) than American classrooms (50%; $t_{(33)} = 2.16$, $p < .05$). In both cultures, the fraction of time spent in academic activities ranged between approximately one third and three quarters (see Table 2.4). Of the observed academic activities, American teachers tended to spend the majority of their time in literacy instruction, whereas the content of Chinese instruction was more varied. American classrooms spent much more time, on average, in literacy instruction than Chinese classrooms (81% vs. 41%). Chinese classrooms tended to spend more time in mathematics and in activities that were coded as "other" (typically puzzles and problem-solving games), but these differences were not significant (see Table 2.5).

Analysis

All analyses were conducted in HLM version 6.8, to account for the sampling of children from classrooms (Raudenbush & Bryk, 2002). With the exception of household income, all continuous variables were standardized in the full sample. Spring EF scores were standardized using the mean and variance from the corresponding fall score, so that growth and changes in variation could be observed. Household income was left in the original transformed scale so that zero represented a child whose household income, adjusted for cost of living, was equal to the mean household income for their country. Gender (female=0, male=1), migrant status (no=0, yes=1), and half-day kindergarten (no=0, yes=1) were entered grand-mean centered, so that the model intercepts were not specific to one group. Half-day kindergarten and migrant status were entered at the classroom level, as all migrant children in our study were in the same class. Culture (US=0, China=1) was entered at the classroom level and was left uncentered so that model intercepts represent predicted scores in the U.S. At the child level, all analyses controlled for the child's age on September 1st of the kindergarten year, gender, parent education, household income, the fall assessment of the outcome variable, and the time between the fall and spring assessments. The inclusion of other fall assessment scores, preschool experience, and interactions between child-level variables and culture were determined by the results of the models in Study 1 (see Chapter II). Time spent in academic activities and time spent in orientation were entered grand-mean centered at the classroom level. Interactions between these variables and culture were also tested. The interaction between academic activities and orientation was not significant for any outcome and thus was not included in any models. As in Study 1, interactions with culture were removed one at a time based on the highest p-value until all interactions were significant at $\alpha = .10$.

Associations between Classroom Activities and Spring EF Skills

ICCs for the kindergarten-exit skills were calculated controlling for fall scores, so that the percentage of variance in growth could be estimated. ICCs for EF growth were moderate (.11 to .35), but were substantially reduced by controlling for culture (to .03 - .25; see Table 2.6). Academic activities and orientation had a moderate negative correlation ($r = -.46$, $p < .01$).

RQ 1: Does time spent in orientation predict children's growth in EF over the kindergarten year, and are the associations consistent across skills and cultures?

Orientation did not predict CF or working memory in either culture. In the U.S., orientation had a small positive association with growth in attentional control ($\beta = 0.24$, $p < .01$). However, a marginally significant interaction term indicated no association between orientation and attention in China (ES = 0.09, $p > .10$; see Table 2.7 and Figure 2.1).

RQ 2: Does time spent in academic activities predict children's growth in EF over the kindergarten year, and are the associations consistent across skills and cultures?

Academic activities had a small association with growth in cognitive flexibility in both cultures ($\beta = 0.11$, $p < .05$). In China, academic activities also had a moderate association with growth in working memory (ES = 0.31, $p < .01$), but this association was not present in the U.S. (see Table 2.7 and Figure 2.2). In the U.S., academic activities had a small positive association with growth in attentional control ($\beta = 0.19$, $p < .01$). However, a marginally significant interaction term indicated no association between academic activities and attention in China (ES = 0.04, $p > .10$; see Table 2.7 and Figure 2.3). Adding orientation and academic activities to the models reduced the predicted cultural gap in attention growth from 0.55 to 0.32 SD and in working memory growth from 0.52 to 0.39.

Discussion

Educators and policymakers have become increasingly focused on identifying educational practices that facilitate children's development of basic cognitive and social skills that enable them to succeed academically in the primary grades (Pianta & Cox, 1999). Recent evaluations of early education curricula and interventions (i.e., Tools of the Mind, Head Start REDI) have attempted to identify programs that can increase these skills (Bierman et al., 2008b; Fuhs et al., 2012, June). However, even when a treatment effect is identified, the results of a program evaluation often cannot identify which component of the intervention caused the observed effect. Interventions can be costly, time-consuming, and difficult to implement on a large scale, making it imperative that we identify specific classroom practices that teachers can easily modify to improve cognitive development. The current study examined two basic classroom activities, orientation and academic instruction, finding that both were predictive to some extent of children's EF development, though further research is needed in order to determine if increasing time in these practices would lead to improvements in children's executive functioning.

In the U.S., time spent in orientation had a small association (ES = 0.24) with children's development of attentional control. In our data, this corresponds to roughly 1.5 months of growth in this skill, which is a meaningful difference at this age. In contrast, more time in orientation did not predict attention growth in China. This difference may be a function of the relative newness of the school environment for the participating American and Chinese samples. The majority of our Chinese sample had already been in their kindergarten school for over two years at the time of the observation, and as a result, were likely very familiar with the routines and activities used by the teachers in that school. Though we observed equivalent proportions of time spent in orientation in the two cultures, Chinese children did not seem to benefit, at least in the development of any EF skill, from this time. Though we cannot address this in this study, it is possible that Chinese children reaped the benefit of time spent in orientation in their first or second year of preschool, contributing to their advantage in kindergarten-entry attention skills (see Chapter II).

American children also saw greater attention (ES = 0.19) and cognitive flexibility (ES = 0.11) growth from more time spent in academic activities. Conversely, Chinese children saw greater *working memory* (ES = 0.32) and cognitive flexibility (ES = 0.11) growth from more time in academics. This difference may be due to the different instructional content that we observed in these classrooms (and that is typically observed in cross-cultural studies of classrooms, i.e., Tobin et al., 2009). Our American classrooms, in line with the heavy national emphasis on literacy instruction in pre-primary and primary classes (Hamre & Pianta, 2007), spent the majority of their academic time in literacy-related activities. These activities, which often included independent reading or teacher-led reading and discussion, may particularly foster attention skills. In contrast, in the Chinese classrooms, we observed a wide variety of instructional content. In particular, we saw a good deal of mathematics and physical problem-solving activities (in two classrooms, children spent the majority of the observed academic time working on picking up a cube using an increasing number of cardboard sticks by combining them to create clamps). Because of the working memory demands inherent in mathematics, these activities may foster the development of working memory skills. Additionally, activities that require visuo-spatial reasoning may enhance children's working memories. In a recent evaluation of an EF training program for preschoolers, Thorell and colleagues (2009) found that training in visuo-spatial working memory activities produced increases in children's verbal working memories.

Alternatively, the differential prediction of academic activities in these cultures may not be the result of differences in the content of instruction, but rather in the nature of the instructional delivery. Studies have found that the way that teachers interact with and question children during instruction is predictive of children's cognitive, and in particular, memory development (Ornstein, Grammer, & Coffman, 2010). A follow-up study that examines cross-cultural differences in the ways that teachers question and give feedback to children, and associations between these interactions and children's EF development, is currently underway.

Time spent in orientation and time spent in academic activities naturally had a negative correlation ($r = -0.46$, $p < 0.05$), as devoting time to one activity leaves less time for the other. However, in American classrooms, it appears that the loss of instructional time resulting from increased time in orientation is beneficial for children's attention skills and likely improves later classroom functioning, as Cameron and colleagues (2005) observed. Interestingly, the association between academic activities and attention growth in American classrooms only emerged when orientation was included in the model, which indicates that academic instruction is only predictive in classrooms in which teachers are able to make good use of their time and engage in substantial amounts of both orientation and academics.

Though we did control for children's skills at the beginning of the school year, these results are correlational and cannot be interpreted in a causal fashion. Additionally, we only observed approximately one hour of one day in each classroom, so the observational data may not be representative of the range of activities that occur in these classrooms. In particular, the American observations all took place during the first hour of the school day, and as most of our American classrooms followed a regular routine with literacy activities in the morning and science and mathematics later in the day, we naturally observed less of these activities in the American classes. However, we do believe that on average, our observation of activities in American and Chinese classrooms is reflective of the typical content and structure of lessons in these cultures. Additionally, we asked teachers to schedule our observations during an academic hour of a typical day, so the total amount of academic instruction observed is likely representative of the class. Finally, it is reasonable to assume that teachers are relatively consistent in the amount of orientation they provide from day to day and activity to activity, so our orientation observations are also likely to be representative.

The findings of this study indicate that natural variation in classroom activities in both the U.S. and China is predictive of the development of multiple domains of executive functioning. The cross-cultural differences in these associations also signify that Chinese and American kindergarten teachers are engaging in different activities that may have different effects on children's cognitive development. These results point to simple changes that teachers can make to enhance their students' EF skills. However, further research is needed to specify the particular types and modes of delivery of academic instruction that promote EF development.

Table 2.1

Participants' Ethnic Backgrounds (Study 2)

	Chinese	
Ethnicity	Number	Percentage
Han	170	86.7
Hui	10	5.1
Mongolian	5	2.6
Man	5	2.6
Korean	3	1.5
Unreported	3	1.5
	American	
Caucasian	117	57.6
African American	10	4.9
Hispanic	6	3.0
Asian	2	1.0
Arabic	9	4.4
Native American	2	1.0
Multiracial	5	2.5
Unreported	52	25.6

Table 2.2

Demographics (Study 2)

	Mean	SD	Range	*N*
	Chinese			
Child's Age at K Entry *(months)*	64.9*	4.2	53 – 75	196
Maternal Age *(years)*	35.3	4.2	25 – 49	190
Paternal Age *(years)*	38.1	4.9	25 – 58	189
Household Income *(yuan)*	115,794*^	89,869	0 – 560,000	143
Parental Education *(years)*				
Maternal Education	14.4	3.2+	6 – 21	187
Paternal Education	14.7*	3.1+	6 – 21	186
Higher of Both Parents	15.1	3.2+	6 – 21	190
Occupational Status				
Mother's ISEI Score	59.7*	14.0	24 – 88	157
Father's ISEI Score	59.6*	14.7	24 – 90	152
Higher of Both Parents	63.8*	13.6	24 – 90	170
	American			
Child's Age at K Entry *(months)*	63.8	4.2	57 – 80	203
Maternal Age *(years)*	35.1	5.7+	23 – 52	130
Paternal Age *(years)*	37.1	6.3+	24 – 58	123
Household Income *(dollars)*	60,488	45,929	0 – 191,000	108
Parental Education *(years)*				
Maternal Education	14.3	2.6	6 – 19	150
Paternal Education	13.6	2.3	6 – 19	142
Higher of Both Parents	14.8	2.5	7 – 19	152
Occupational Status				
Mother's ISEI Score	51.6	15.9	24 – 88	102
Father's ISEI Score	49.9	16.2	10 – 88	110
Higher of Both Parents	54.1	15.8+	24 – 88	136

Note. * Indicates that the mean is higher for this culture as compared to the other.
+ Indicates that the variance is higher for this culture as compared to the other.
^ The mean comparison for household income was calculated using the transformed data; see *Measures* section.

Table 2.3

Rates of Missingness for Key Variables (Study 2)

	U.S.	China
Household Income	59%	28%
Parental Education (Higher of Both Parents)	31%	7%
Total Preschool Hours	48%	9%
Fall Attention	1%	0%
Fall Working Memory	28%	2%
Fall Cognitive Flexibility	0.5%	0.5%
Spring Attention	3%	9%
Spring Working Memory	7%	9%
Spring Cognitive Flexibility	3%	9%

Table 2.4

Classroom Activities in the U.S. and China

	Mean (%)	SD	Range	*N*
	Chinese			
Orientation	.10	.07	.03 - .30	14
Academic Instruction	.59*	.14	.37 - .83	14
Free Play	.09	.09	.00 - .30	14
Ritual	.05	.07	.00 - .19	14
Transition	.15	.07	.02 - .29	14
	American			
Orientation	.10	.07	.00 - .28	21
Academic Instruction	.50	.12	.30 - .72	21
Free Play	.05	.08	.00 - .23	21
Ritual	.19*	.10	.06 - .45	21
Transition	.14	.06	.06 - .27	21

Note. * Indicates that the mean is higher for this culture as compared to the other.

Table 2.5

Proportion of Class Time Spent in Different Academic Activities

	Chinese			
	Mean	SD	Range	N_{obs}
Language Arts	.41	.47	0.0 – 1.0	7
Mathematics	.17	.37	0.0 – 1.0	4
Science/Social Studies	.09	.24	0.0 - .83	3
Art/Music	.06	.16	0.0 - .59	3
Practical Life	.06	.21	0.0 - .78	3
Other	.21	.36	0.0 - .98	4
	American			
Language Arts	.87*	.30	.33 – 1.0	21
Mathematics	.04	.04	0.0 - .14	16
Science/Social Studies	.01	.03	0.0 - .11	2
Art/Music	.13	.24	0.0 - .67	6
Practical Life	0.0	0.0	0.0 – 0.0	0
Other	.01	.03	0.0 - .13	2

Note. * Indicates that the mean is higher for this culture as compared to the other. N_{obs} indicates the number of classrooms in which this type of instruction was observed.

Table 2.6

Intraclass Correlations of Spring EF Scores

	Attention	WM	CF
Fully Unconditional Model	.23**	.24**	.14**
Model Controlling for Culture	.07**	.17**	.07**

Note. * p<.05; **p<.01. Stars indicate the significance of the between-classroom variance.

Table 2.7

Associations between Classroom Activities and Spring EF Skills

	United States					
	Attention		Working Memory		Cognitive Flexibility	
	Est.	St. Err.	Est.	St. Err.	Est.	St. Err.
Intercept	0.96**	0.11	0.57**	0.07	0.56**	0.12
Culture (China=1)	0.32**	0.09	0.39*	0.14	-0.06	0.20
Migrant (Yes=1)	0.24	0.18	-0.48*	0.19	0.13	0.18
Half-day (Yes=1)	-0.21	0.13	-0.29	0.20	0.05	0.15
Academic Activities	0.19**	0.06	-0.03	0.08	0.11*	0.05
Ac. Act. x Culture	-0.15+	0.09	0.35**	0.11	---	---
Orientation	0.24**	0.05	-0.02	0.07	0.01	0.06
Orientation x Culture	-0.16+	0.08	---	---	---	---
Fall Attention	0.37**	0.05	0.11*	0.04	0.10*	0.05
Fall Working Mem.	0.07	0.05	0.50**	0.05	0.26**	0.05
Fall Cognitive Flex.	---	---	0.07	0.05	0.29**	0.06
Time b/t Tests	0.05	0.05	0.18**	0.07	0.07	0.05
Age	0.13**	0.05	0.01	0.04	-0.05	0.05
Parental Education	0.24*	0.11	0.12+	0.06	0.11	0.07
Par. Ed. x Culture	-0.20	0.12	---	---	---	---
Household Income	0.17**	0.05	-0.08	0.07	0.13	0.10
Gender (Male=1)	-0.12	0.09	0.04	0.09	0.28	0.19
Gender x Culture	---	---	---	---	-0.62+	0.33
Preschool Hours	---	---	---	---	0.04	0.14
Preschool x Gender	---	---	---	---	0.33+	0.17
ICC of residual var.	.01		.12**		.01	

Note. +p<.10;* p<.05; **p<.01. (---) indicates that the variable was not included in the model for that outcome. Stars in the ICC row indicate indicate the significance of the between-classroom residual variance. Gender and Migrant were entered grand-mean centered, and Culture was entered uncentered, so the intercept represents children in the U.S. Household income was left in the original transformed metric so that zero represents average household income in one’s country, and all other continuous variables were standardized in the full sample.

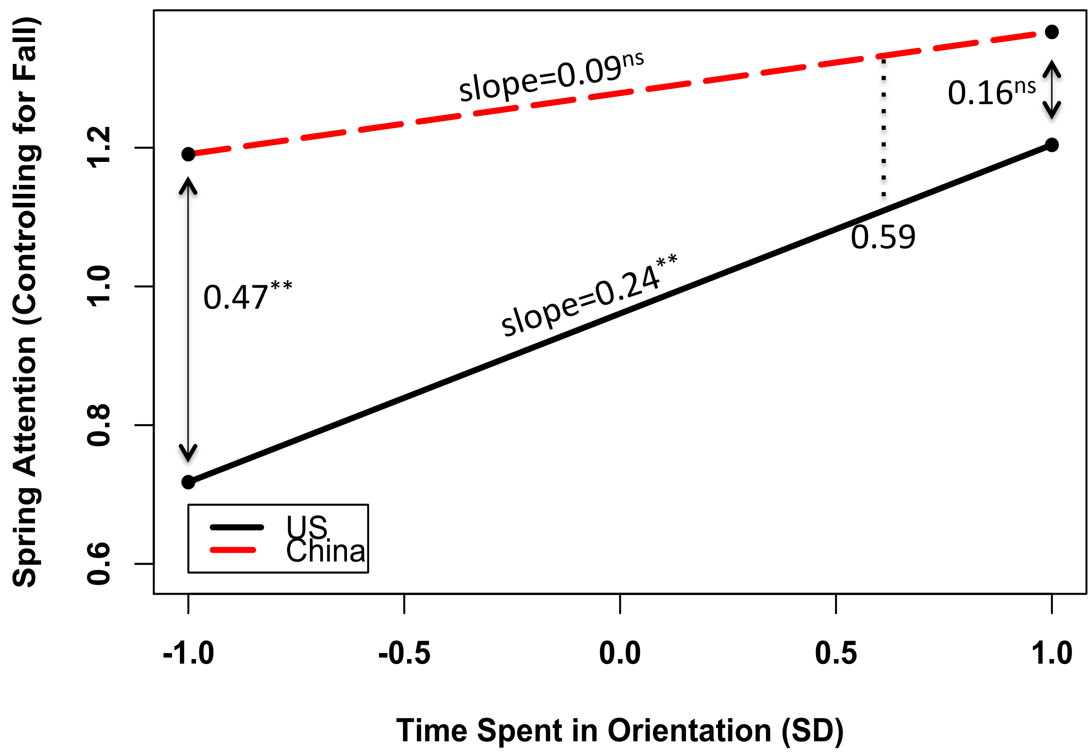

Figure 2.1. Time Spent in Orientation Predicts Attention Development in the U.S. The cultural gap in attention growth is significant when orientation time is less than 0.59 SD above the mean (shown in the graph as a vertical dashed line). In classrooms 1 SD below the mean in orientation, Chinese children are predicted to outgrow American children in attention by 0.47 SD over the kindergarten year.

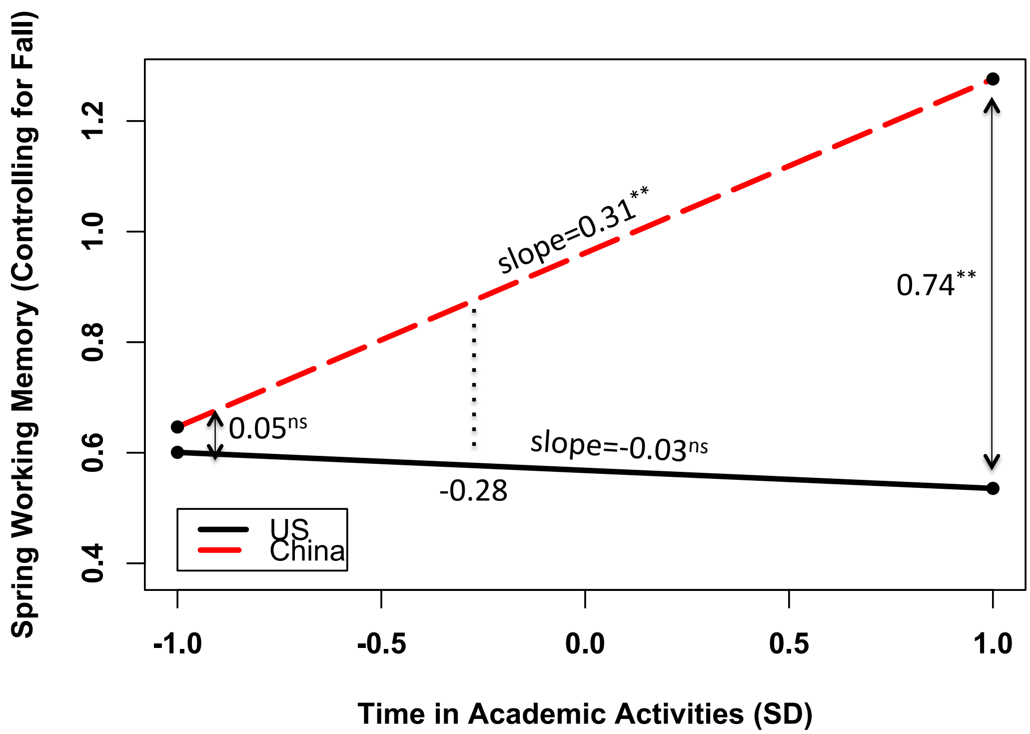

Figure 2.2. Time Spent in Academic Activities Predicts Working Memory Development in the U.S. The cultural gap in working memory growth is significant when academic activity time is greater than 0.28 SD below the mean (shown in the graph as a vertical dashed line). In classrooms 1 SD above the mean in academic activities, Chinese children are predicted to outgrow American children in working memory by 0.74 SD over the kindergarten year.

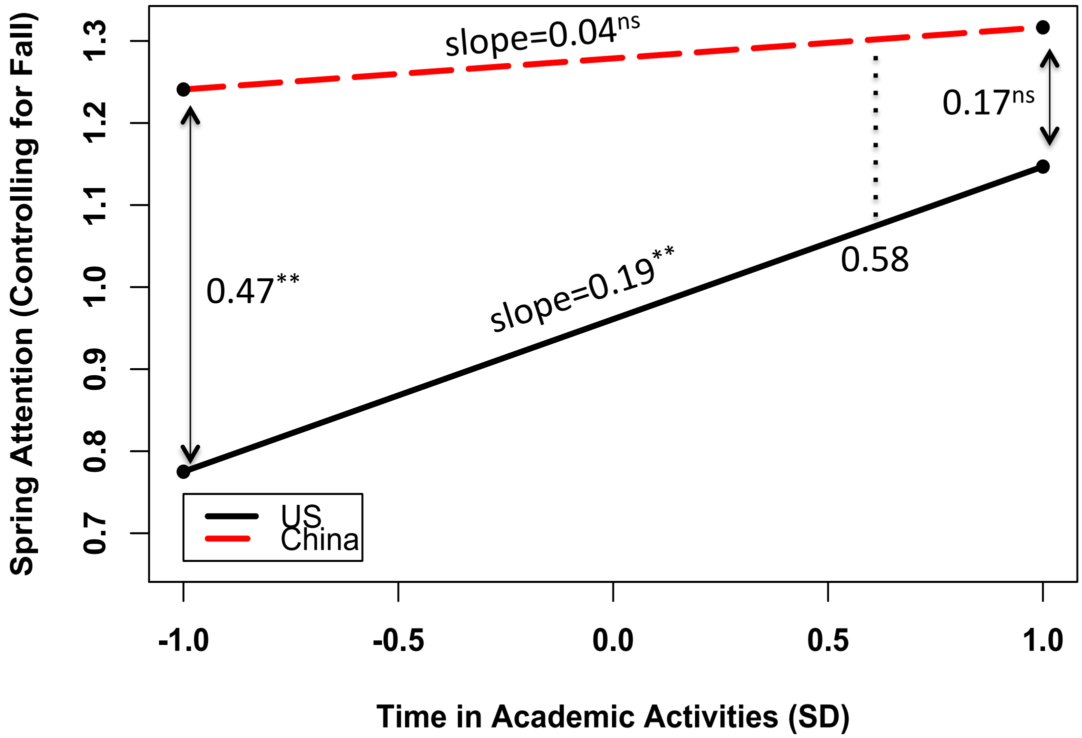

Figure 2.3. Time Spent in Academic Activities Predicts Attention Development in the U.S. The cultural gap in attention growth is significant when academic activity time is less than 0.58 SD above the mean (shown in the graph as a vertical dashed line). In classrooms 1 SD below the mean in academic activities, Chinese children are predicted to outgrow American children in attention by 0.47 SD over the kindergarten year.

Chapter IV

Limitations, Conclusions, and Implications

Limitations

As this study is based on correlational methods, results cannot be interpreted in a causal fashion. These samples were selected based on access to schools and are not representative of all American and Chinese children, and thus our findings may not generalize to all subgroups in these cultures. We also had no assessment of children's skills or traits when entering preschool, and though we did our best to adjust for family background differences, the observed associations between preschool and EF skills could be due to pre-existing differences in children's skills or other unmeasured variables, such as parents' motivation for their children's academic success. This confounding effect may be particularly present in China, where parents must compete for coveted spots in the public preschools from which most of our sample was recruited. Additionally, the Chinese sample was more advantaged than the American sample. Our socioeconomic measures were imperfect, and as a result, we may have overestimated the EF gap between Chinese and American children and underestimated the influence of SES on EF skills. Furthermore, some socioeconomic measures and the fall working memory assessment had high rates of missing data, increasing the variability of these measures and potentially attenuating their associations with other variables.

Additionally, this study only measured three components of EF, leaving unanswered how other aspects of EF (i.e., inhibition, delay of gratification) are influenced by preschool and kindergarten experiences in these cultures. We also used a rough measure of children's preschool attendance, which leaves us unable to draw specific conclusions about the reasons for the associations between preschool and EF. Finally, our kindergarten observational data is based on only one hour of one day in each classroom and thus may not be representative of the range of activities that typically occurs in each class.

Conclusions

The findings of these two studies point to four major conclusions: (1) the Chinese advantage in EF skills is sizeable, persists through the end of kindergarten, and cannot be attributed solely to socioeconomic differences between samples; (2) urban Chinese children's greater access to high-quality preschool may be contributing to their EF advantage; (3) gender differences in these skills are not universal and may be due to or mitigated by environmental factors; and (4) natural variation in typical classroom activities is predictive of EF development.

Because "culture" encompasses many different contexts at the micro, meso, and macro levels (Bronfenbrenner, 1979), the simple identification of a culture gap in skills does not permit causal conclusions about the origin of one group's advantage. However, a cultural difference does provide strong evidence for environmental influences. In the bioecological model of development (Bronfenbrenner & Morris, 2006), *proximal processes*, in which individuals interact with their environment, are the mechanisms causing developmental change. Both the features of the person and the characteristics of the environment influence the proximal processes that occur and the impact they have on development.

The cultural gap we observed could be explained either by innate differences between American and Chinese children or by differences in their environments. Researchers have found that the 7-repeat allele of the DRD4 dopamine receptor gene, which is associated with ADHD and thus poor EF performance (Faraone, Doyle, Mick, & Biederman, 2001; Schachar, Tannock, Marriott, & Logan, 1995), is much less prevalent in China (1.9%) than in the United States (48.3%; Chang, Kidd, Kivak, Pakstis, & Kidd, 1996). This genetic difference could be related to Chinese children's EF advantage. However, to date we know of no research that has connected the 7-repeat allele variation in EF skills in typically developing populations, making this explanation hypothetical at this point.

In contrast, we know a great deal about differences in young children's contexts in China and the U.S. First, these two cultures are embedded in different macrosystems that perpetuate diverse values (i.e., individualism in the U.S.; collectivism and Confucian self-improvement in China; Li, 2003; Triandis & Gelfand, 2012). Second, Chinese and American children experience microsystem differences both at home and at school. Most urban Chinese children have no siblings as a result of the one-child policy (Hu & Szente, 2009), in contrast to American children, who have one sibling on average (U.S. Census Bureau, 2010a). Research has also identified cultural differences along a number of parenting dimensions, including directiveness, protection, and shaming (Chinese mothers scored higher), and warmth/acceptance and democratic participation (American mothers were higher; Wu et al., 2002). Chinese and American parents also differ with respect to their beliefs about academic achievement, with Chinese parents more often attributing success to effort and American parents attributing success to innate ability, which likely translates into the way they interact with children around schoolwork (Stevenson et al., 1993). These parenting differences almost certainly lead to differences in children's development in the first years of life, and likely contribute to the EF gap that we observed, although this study is unable to assess these associations empirically.

However, we did directly observe differences in children's preschool experiences (Chinese children spent much more time in preschool) and kindergarten classroom environments (Chinese children spent more time engaged in academic activities, and the content of those activities differed from American children's activities). Additionally, we observed variation in the ways that these environments influenced children (more time in preschool predicted school-entry attention in China, but not the U.S.; more time in academic activities predicted attention in the U.S., but working memory in China). These varying associations indicate that either (1) the environments differ greatly enough to lead to different outcomes, or (2) children in the two cultures are interacting differently with their environment as a result of differences in their own individual characteristics. In either scenario, the proximal processes that children experience in early education settings are not the same in the U.S. and China, and our results indicate that these diverse processes contribute to differences in children executive function development.

The bioecological model (Bronfenbrenner & Morris, 2006) also provides an excellent framework for understanding gender differences in children's development. As with cultural differences, gender gaps could be due completely or partially to innate biological differences between boys and girls (i.e., variation in prenatal hormone exposure, dissimilar timing of the development of particular brain structures; Kalhut et al., 2009). However, our findings indicate that the gender gap is likely influenced by environmental factors, as these gaps were not consistent across cultures. One potential environmental explanation is again differences in parenting. Research on Chinese parenting indicates that parents may exert higher levels of control over boys than girls (Chang, Schwartz, Dodge, & McBride-Chang, 2003; Chen, Liu, & Li, 2000), perhaps in an attempt to counterbalance an innate male tendency toward weaker self-control. In contrast, a study of American parents found that parents were more likely to grant autonomy to boys than to girls (Pomerantz & Ruble, 1998).

The smaller EF gender gaps found in Chinese children could also be due to differences in early schooling or to a combination between school and home factors. Chinese boys may be disadvantaged relative to girls upon entering preschool, but these differences may be gradually weakened by the demands of the schooling environment, or by the combination of school and parental control. Alternatively, there may be no biologically driven gender differences in these skills. The gender gaps that we observed in the U.S. may be completely due to differential treatment of boys and girls at home and at school (see Ruble, 2006, for a review), and this differential treatment may be less prevalent in China. However, the current study is not able to address the reasons for these gender gap differences, and future research is needed to identify the environmental factors that exacerbate or attenuate gender differences in EF development.

The results of these studies highlight the importance of considering differences at every level of analysis when examining developmental processes. As Bronfenbrenner (1979) argued over three decades ago, children are affected by both immediate and distal contexts and by interactions among these contexts, and studies of development should account for these multiple levels of environmental influence. Though our studies focused on one microsystem, schooling experiences, the findings support the larger theoretical arguments of the bioecological model (Bronfenbrenner & Morris, 2006).

Implications for Practice and Policy

American educators have long been concerned with American students' poor academic performance, particularly in mathematics and science, relative to children from East Asian and other developed nations (National Commission on Excellence in Education, 1983), and more recently, with the apparent decline of boys' academic and social achievement (Gurian & Stevens, 2005). Our findings signify that these are not separate issues: in fact, China's greater achievement may be related to its ability, either through different cultural expectations, parenting practices, or educational experiences, to prevent large disparities from emerging between the genders. Additionally, our results highlight the importance of access to early education in both countries and of examining the content of classroom activities to determine the best educational environment for young children's development.

Our findings indicate that Chinese preschool and kindergarten classrooms are producing different cognitive outcomes than American classrooms. In China, but not in the U.S., preschool attendance predicted school-entry attention, and academic activities in kindergarten predicted growth in working-memory. These differential associations indicate that American classrooms may not be living up to their potential in terms of facilitating children's cognitive development. American kindergarten has become increasingly focused on literacy instruction over the past decade (Hamre & Pianta, 2007), and though this instruction may improve children's attention skills, children's working memory development might benefit from more varied instruction that includes more mathematics and problem-solving activities. Additionally, our results, in combination with the findings of prior work (e.g., Cameron & Morrison, 2011), demonstrate that more time spent in the fall orienting children to activities and procedures may promote greater EF skill development.

Surveys of kindergarten teachers have found that they are primarily concerned with children's abilities to function in a classroom and much less concerned that they arrive with academic skills such as knowledge of the alphabet (NCES, 1993). Additionally, a nationally representative survey of kindergarten teachers found that almost half of teachers believed that the majority of children in their classes were not adequately prepared for school (Rimm-Kaufman, Pianta, & Cox, 2000). These findings point to the need for better and more widely available preschool programs. For the American children in this study, more time in preschool led to better school-readiness skills, in the form of higher levels of working memory and cognitive flexibility. Our measure of time in preschool was a combination of hours per week and months of attendance, so we were not able to determine from this analysis whether duration or intensity was the primary factor of influence, or whether both were necessary to see an impact on EF skills. However, the results indicate that American children would benefit from some combination of access to preschool at an earlier age (many publicly funded programs are only available in the year before kindergarten entry) or with greater intensity (programs are often only half-day or a few days per week; NIEER, 2011).

After observing these differences in Chinese and American children's EF skills and early education experiences, it is tempting to conclude that altering American children's preschool and kindergarten environments to more closely resemble those in urban China would lead to substantial improvements in American EF development. However, Chinese children's advantages stem from a complex combination of factors, not all of which are immediately transferable to Western culture. One simple (though expensive) change that American policymakers could make would be to provide universal full-time preschool beginning at age three, to match the experience of the typical Chinese child in this sample. As we observed in the American sample that more time in preschool was associated with greater working memory and cognitive flexibility, this policy change could lead to higher average WM and CF scores. However, it is unclear whether providing universal early access to preschool would also lead to greater attention skills, as was seen in the Chinese sample. It is possible that Chinese children's attention gain resulted simply from time spent in a classroom environment, but more likely, it is the result of Chinese preschools' particular focus on socializing attention, which stems from the Confucian approach to education (Li, 2003; Tobin et al, 1989). This focus on attention would be more difficult to transfer to American preschools, as it is rooted in widespread beliefs, among both parents and educators, about what young children should be expected to do and how they should be educated. However, it is possible that a preschool curriculum based on the Chinese approach to socializing attention could be developed and could be effective, if both parents and teachers believed in and supported such an approach.

Additionally, American and Chinese parents have different child-rearing beliefs and practices which likely affect children's executive functioning (see discussion above). American parents are not likely to alter their daily parenting practices en masse, and if individual parents began adopting Chinese practices, these approaches likely would not lead to the same outcomes, since they would not be in line with teachers' approaches or with the community's norms. Finally, there are some cultural differences (i.e., social policies like the one-child policy and possible genetic differences) that may provide Chinese children with an unalterable EF advantage. However, our results indicate that EF skills in both cultures could be improved through educational intervention.

In the U.S., government agencies fund between one quarter and one third of the cost of childcare and preschool, leaving at least two thirds of the cost to be paid by parents. Government funds for preschool are more often made available only to families below a certain income threshold, leaving working- and middle-class families without access to an affordable preschool. Additionally, private preschools for middle-class families are often of questionable quality. These programs often have poorer working conditions and low wages, resulting in less-qualified teachers (only 36% of teachers in private preschools have more than an associate's degree, as compared to 87% of teachers in preschools based in public schools; Fuller et al., 2007). As a result, only a third of American three-year-olds and just under three-quarters of four-year-olds attend preschool, and many, if not a majority, of these children are in programs that are not considered high quality (NIEER, 2011; U.S. Census Bureau, 2010a).

Economists project that investing in high-quality early education would lead to large returns on investment as a result of decreases in crime and dependence on social support and increases in adult earnings and productivity (i.e., Heckman, 2006). At a meeting of the Committee for Economic Development, Isabel Sawhill of the Brookings Institution estimated that the creation of universal preschool would increase the nation's gross domestic product by $988 billion in a period of sixty years (Fuller et al., 2007).

Though this estimate is an extrapolation and may be over-reaching, the evidence from this study and many others clearly converges at the same point: both American and Chinese children would benefit from increased access to high-quality early education and from rigorous investigation of the best practices for promoting optimal cognitive and academic development.

Future Directions

In the larger project from which the current studies were conducted, children's kindergarten classrooms were also observed at the end of the school year. Coding of these observations has recently been completed, which will allow us to examine changes over the school year in orientation and academic activities and in how these changes are associated with EF growth. Additionally, to further examine the influence of academic activities on children's EF development, we are currently coding the types of questions that teachers ask during academic instruction in each culture and the feedback that they give children on their answers. If Chinese and American teachers differ in these behaviors, this difference could identify a process through which Chinese teachers are having a greater impact on children's working memory development.

Recent evaluations of preschool interventions have found that at least part of the programs' impacts on academic achievement can be attributed to increases in EF and self-regulation (Bierman et al., 2009; Raver et al., 2011). The current project also evaluated children's mathematics and literacy skills at the beginning and end of kindergarten, enabling us in future studies to explore preschool and kindergarten effects on Chinese children's greater academic achievement and the possible mediating role of EF skills in these pathways. Since Stevenson and colleagues' (1986) landmark paper detailing Chinese children's academic advantage, researchers and educators have been searching for explanations, which range from innate biological and genetic differences to larger societal expectations and influences. Our research highlights the fundamental role of early education in the development of these skills and in the long-standing culture gap. As American educators and researchers have argued for decades, investing in early education would improve children's achievement and school success and would likely make great strides in our effort to catch up academically with China and other industrialized nations.

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