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Association of Parent–Child Relationships and Executive Functioning in South Asian Adolescents

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Objective: It is known that some environmental variables can significantly affect the development of executive functions (EF). The primary aim of this study was to analyze whether some family conditions, such as the adolescent's perception of the quality of parent–child relationships and the socioeconomic status (SES; assessed according to education, occupational status, and income) are significantly associated with EF test scores. ***Methods:*** There were 370 Pakistani participants ranging in age 13 to 19 years who were selected and then individually administered the following tests taken from the Delis–Kaplan Executive Function System (D–KEFS): Trail Making Test (TMT), Design Fluency Test (DFT), Color Word Interference Test (CWIT), and Card Sorting Test (CST). In addition, a Parent–Child Relationship Scale (PCRS) also was administered. ***Results:*** Results showed that perceived "neglect" in the PCRS was negatively associated with the 4 EF test scores. Parents' education and SES were positively associated with 3 EF measures: DFT, CWIT, and CST. Further correlational analyses revealed that inhibition (as measured with the CWIT) and problem-solving ability (as measured with the CST) were significantly associated with the perceived parent–child relationships. Some gender differences also were observed: males outperformed females on TMT, DFT, and CST, while females outperformed males in the CWIT. ***Conclusion:*** It was concluded that perceived parent–child relationships, SES, and parents' education are significantly associated with executive function test performance during adolescents.

Keywords: parent–child relationship, executive functions, D-KEFS Tests

Executive functions (EF) are a constellation of higher order cognitive mechanisms such as working memory, abstraction, strategy development, inhibition, cognitive flexibility, and cognitive switching (e.g., Fuster, 2008; Jurado & Rosselli, 2007; Lezak, 1983; Stuss & Levine, 2002). Several studies have indicated that these executive skills continue to develop across childhood and adolescence (e.g., Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Kramer, 2014), which are associated with diverse prefrontal cortex changes (Spear, 2000). Although the gross volume of brain remains stable after the age of 5 (Paus et al., 2001), MRI studies have demonstrated a nonlinear loss of gray matter (Sowell, Thompson, Tessner, & Toga, 2001) along with a linear gain of white matter, particularly myelination, during the adolescent years (Giedd et al., 1999; Paus, 2010; Pfefferbaum et al., 1994). Those changes are especially prominent in the frontal areas of the brain (Reiss, Abrams, Singer, Ross, & Denckla, 1996).

The maturing prefrontal cortex is known to be particularly susceptible to environmental influences in the critical stage of adolescence (e.g., Noble, Norman, & Farah, 2005). Steinberg (2002) emphasized the critical role of the environment in shaping the psychological processes during adolescence. Although some theoretical studies (e.g., Carlson, 2003; Lewis & Carpendale, 2009) have analyzed the significance of social factors on EF development, limited empirical research approaching the effects of family conditions on EF development is currently available.

Many authors, including Vygotsky (1980) and his followers (e.g., Ardila, 1995; Cole, & Scribner, 1974; Luria, 1976), have emphasized the crucial influence of environmental/cultural factors on cognition. This interest in the effects of environmental/cultural variables in intellectual abilities has resulted in the development of a new research and clinical area usually referred as "cross-cultural neuropsychology" (Fletcher-Janzen, Strickland, & Reynolds, 2000; Uzzell, Ponton, & Ardila, 2013). Guided by these previous models, in particular Vygotsky, current research has begun analyzing the effects of environmental/living conditions on cognition.

Diverse studies have suggested that socioeconomic status (SES) has a significant association with a child's intellectual development in general (Andersson, Sommerfelt, Sonnander, & Ahlsten, 1996; Duncan, Brooks-Gunn, & Klebanov, 1994; White, 1982) and with EF in particular (Noble et al., 2005). By the same token,

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several studies have suggested that a parents' educational level represents a crucial factor that correlates with their child's cognitive development (Ganzach, 2000; Teachman, 1987; White, 1982) and particularly with the development of EF (Klenberg, Korkman, & Lahti-Nuuttila, 2001). Highly educated parents provide an intellectually stimulating environment for their children and use a richer vocabulary (Hoff, 2003; Hoff-Ginsberg, 1991). In addition, family income, another important indicator of SES, also was described as associated with cognitive development by Lynn and Vanhanen (2002, 2006), who found a strong positive correlation between per capita income and national IQ scores.

Different studies also have supported the crucial role of parenting in predicting the cognitive development during adolescence (e.g., Dornbusch, Ritter, Leiderman, Roberts, & Fraleigh, 1987; Hickman, Bartholomae, & McKenry, 2000; Leung, Lau, & Lam, 1998). Due to this, it seems evident that the quality of the parent–child relationship can affect the cognitive development in general and EF in particular.

It has been observed that adolescents, whose parents provide a nurturing, responsive, and loving environment show a healthier social adjustment than adolescents receiving abusive, neglecting, and rejecting treatment from their parents (Doyle, Moretti, Brendgen, & Bukowski, 2004; Watson & Fischer, 2002). The association of positive parenting along with a highly cohesive and organized family environment, with improved regulation of EF has been described by Schroeder and Kelley (2009) in children and early adolescents. Khan (1999) described the positive relationship between creativity (an executive ability) and perceived authoritative/permissive parenting style in Pakistani South Asian adolescents. Khan proposed that perceived permissive parenting facilitates creativity in adolescents, unlike authoritarian parenting.

On the other hand, the negative influence of unfavorable parenting on brain development (e.g., De Bellis, 2005) that affects the developmental progression of cognitive and executive skills also was evident in diverse empirical studies (e.g., Hughes & Ensor, 2009; Rutter & O'Connor, 2004). There is a sizable body of research documenting the detrimental effects of child abuse (Teicher, 2000; Weniger, Lange, Sachsse, & Irle, 2008), maltreatment, and neglect (Cicchetti, 2002; Glaser, 2000) on brain development and EF. Mezzacappa, Kindlon, and Earls (2001) described that normal improvement with increasing age in inhibitory capacities (an executive skill) decreased in abused, as compared with nonabused, children.

However, it is worth considering that South Asian adolescents have an increased risk of exposure to violence in their homes, that is, between 41 and 88 million children witness violence at home—the highest regional total in the world (Pinheiro, 2006). It is alarming that there is a lack of research on parent–child relationship styles and their effects on neurocognitive development in this population. To address this gap, one major objective of the current study was to identify the association of parent–child relationships on EF development in Pakistani South Asian adolescents.

The purpose of current study was to examine EF in Pakistani adolescents from South Asians ethnic background by assessing their performance on four Delis–Kaplan Executive Function System (D–KEFS) tests (Delis, Kaplan, & Kramer, 2001): Trail Making Test (TMT), Design Fluency Test (DFT), Color Word Interference Test (CWIT), and Card Sorting Test (CST). The study intended to examine the association of perceived parent–child relationships and SES/educational level with these four EF test scores; as well as the influence of age and gender with regard to the development of EF. It was predicted that the quality of parent–child relationships as well as the parents' SES/education would significantly correlate with the developmental progression of these executive skills.

Method

Participants

Random sampling technique was used to collect data from the widely scattered public secondary and higher secondary schools in the Lahore cosmopolitan area based on the list of schools obtained from the Director of Public Instructions (DPI schools) of Lahore. From the two separate school lists for boys and girls, researchers randomly picked 20 schools, 10 girls' schools and 10 boys' schools. However, data could not be obtained from all the 20 schools because of administrative problems in three of the schools: one boy's school and two girl's schools. Therefore, there were only 17 schools included in the test sample.

Of 398 total letters sent to parents (parents of students who volunteered and were fulfilling the study's criteria), 384 gave consent for their child's participation; of remaining 14 children, 12 students did not bring back their parent's consent (they were absent or forgot to bring it back). Finally, of 384 participants, data from 14 students were excluded due to various reasons (e.g., the participant left one or two scales incomplete; the participant could not complete all the assessment tests; the demographic related information was not provided; etc.).

Inclusion criteria were as follows: reading in secondary and higher secondary grades and having normal or corrected-to-normal vision and hearing. Exclusion criteria included parental history of alcohol or drug abuse, having history of traumatic brain injury or any other neurological illness, and having some learning or reading difficulty.

Participants involved were 370 community-dwelling adolescents from Lahore (second largest city in Pakistan and fifth largest city in south Asia), a cosmopolitan area with a population of around 10 million. The sample included 175 males and 195 females (age range = 13–19 years; $M_{age} = 15.56$, $SD = 1.34$). They were divided into two age groups, in general corresponding to early adolescents (age range = 13–15 years, $M_{age} = 14.56$, $SD = 0.54$) and late adolescents (age range = 16–19 years, $M_{age} = 17.16$, $SD = 0.83$). Demographic characteristics of the participants in the two age groups appear to be similar as presented in Table 1.

The sample was recruited during 2009; nonetheless, Pakistan's social, cultural, and living conditions have not significantly changed (United Nations Development Programme, 2015).

Instruments

Neurocognitive assessment. Four tests taken from the D–KEFS (Delis et al., 2001) were used to examine EF.

TMT consists of five conditions: visual scanning (Condition 1), number sequencing (Condition 2), letter sequencing (Condition 3), number–letter switching (Condition 4), and motor speed (Condition 5). Condition 4 requires the examinee to connect circles while switching between numbers and letters; it specifically examines

Table 1
Demographic Information of the Sample

Demographic variables	Ages 13–15 (n = 191)			Ages 16–19 (n = 179)			Total		
	M	Mdn	*SD*	*M*	Mdn	*SD*	*M*	Mdn	*SD*
Age	14.56		0.54	17.16		0.83	15.8		1.3
Male:female	90:101			85:94			175:195		
% right-handed	96			98			97		
Father's education	4.26	4	2.07	3.97	4	2.03	4.11	4	2.05
Mother's education	3.40	3	2.24	3.28	3	2.16	3.34	3	2.27
Father's occupation	5.46	6	2.08	5.14	5	1.99	5.31	6	2.05
Mother's occupation	3.82	3	1.75	3.90	4	1.42	3.87	3	1.62
Family income[a]	5.94	6	3.48	6.15	6	2.94	6.05	6	3.28
SES	22.88	23	8.48	22.45	22	7.06	22.68	23	7.09
Male	22.49			22.36			22.42		
Female	23.27			22.54			22.91		

Note. N = 370. Educational categories based on a scale ranging from 0 (*no formal years of education*) to 8 (*post graduate/more than 16 years of education*). Occupational categories based on a scale ranging from 0 (*unemployed*) to 10 (*senior professional job*). Income categories based on a scale ranging from 1 (*less than 5,000 Pak Rupees per month*) to 8 (*1,000,000 Pak Rupees or above per month*) for each source separately. SES was calculated using parental education, parental occupation, and family income. SES = socioeconomic status.
[a] Family income was the sum of income from three sources: mother, father, and other.

cognitive flexibility. The first four conditions were administered to the participants to assess cognitive flexibility after accounting for visual and sequencing speed. Completion time was taken as the raw score for each condition. The combined number and letter conditions (Conditions 2 & 3) measures the basic numerical and verbal ability (BNVA); whereas the score in the switch condition (Condition 4) measures the examinee's cognitive flexibility (CF).

DFT requires the examinee to draw different designs by using four lines. It consists of three conditions: basic, filter, and switch. In basic and filter conditions, the examinee is required to draw different designs by joining filled dots together, or the empty dots. In switching, the participant alternates between filled and empty dots to draw designs. Each condition was preceded by a practice session. The number of correct designs in each trial was taken as the dependent variable. The number of errors also was noted during evaluation but not calculated in the final score. The sum of the scores of first two conditions (basic and filter) was defined as the "nonswitch design fluency" (NSDFT) and the score of the third condition (switch) was considered the "switch design fluency" (SDFT).

CWIT examines the ability to inhibit a dominant and automatic response in favor of a new response. It consists of four conditions: color naming, color name reading, telling the names of colors printed in a different color ink, and switching between reading the color name and naming the dissonant ink color. The raw score is the time required to complete the task. The score on the combined color naming and word reading task (Conditions 1 & 2) measures the fundamental linguistic skills (FLS). The sum of scores on inhibition and switching (Conditions 3 & 4) defines the examinee's cognitive flexibility and verbal inhibition (CFVIT). The sum of the number of errors in Conditions 3 and 4, included in the final analysis, was taken as measure of verbal inhibition (VIE).

CST requires the examinee to sort six cards into two sets with each set having three cards, on the basis of some common principle with a maximum of eight different sorts. It measures problem-solving and concept formation skills. In the free-sort condition, the examinee is required to sort six cards into two sets followed by the verbal description of sorting strategy; it was scored between zero and four points per description according to the accuracy and abstraction level (free description score; FDS). The main dependent variable in this study was the problem-solving ability (PSA) score that included the total correct sorts and the total FDS.

Although the selected subtests were considered to be performance tests, the instructions were verbally administered. Prior to the use in this study, the instructions were translated into Urdu by forward translation followed by the back translation into English language by bilingual experts. English translation was compared with the original English instructions to check equivalence in connotation, meaning, and grammatical form of new translation with the original one. No significant discrepancy was revealed in the original English and back-translated English version.

PCRS. The Parent–Child Relationship Scale (PCRS), developed by Rao (2000), measures the quality of parent–child relations perceived by adolescents between 12 and 18 years of age. This 100-item instrument has been shown to have acceptable validity in comparison to the Bronfenbrenner Parent Behavior Questionnaire as well as the Indian adaptation of the Child Report of Parental Behavior Inventory. This yields a full-scale parent–child relationship score along with 10 subscale scores of both positive and negative dimensions including Loving, Object Reward, Protecting, Symbolic Reward, and Demanding; Indifferent, Neglecting, Object Punishment, Rejecting, and Symbolic Punishment, respectively. The child, then, responds to each item on a 5-point scale ranging from 5 (*always*) to 1 (*very rarely*) for both mother and father, separately. Therefore, the maximum score for each parent can be 500 and ultimately, 1,000 for both parents.

The PCRS had been translated into Urdu as part of another study (Fatima & Sheikh, 2014). The Urdu version was cross-validated in a sample of 100 bilingual adolescents between 13 and 19 years of age. Descriptive statistics (means and standard deviations) of both the English and Urdu versions were comparable with no major discrepancies. The correlation between the total scores and the subscale scores of English and Urdu versions were found to be significant at the .01 level ranging between .74 and .95. Cronbach's alpha reliability coefficient of internal consistency was also calculated for the 10 subscales of the new Urdu version ranging between .66 and .85, revealing satisfactory consistency of items. Test–retest reliability coefficient administered over a period of 10 days was found to be .88 for the total score of the Urdu version. This ranged from .76 to .91 for the 10 subscale scores.

Demographic information sheet. The demographic information sheet was used to obtain demographic and SES related information (parents' education, parents' occupation, and family income). This sheet was developed by listing the three most commonly used indicators of SES (education, occupational status, and income; McLoyd, 1998). Educational categories defined in the Pakistan Bureau of Statistics (1998) were used to measure parents' educational level. These categories have not changed since the 1998 report. Scores for educational levels were rated on a scale ranging from 0 (*0 years of education*) to 8 (*16 or more years of education; masters, M Phil*, *PhD, etc.*). Two questions were included to measure father's and mother's occupation. According to Pakistan Bureau of Statistics (1998), the maximum score of 10 was given to *senior professionals* and the minimum score of 0 was given to *unskilled employment*. For the measurement of composite family income, three questions determined the father's, mother's, and other sources of income. The composite score of SES was calculated by summing up the items measuring the three variables (McLoyd, 1998).

Procedure

Initial contacts were established with school principals and they were informed about the purpose and nature of the study. At the same time, a letter was sent to the parents to obtain their consent for their child's participation in the study.

After obtaining the consent, assessments were conducted in two sessions. In first session (about 1 hr), after having participants comfortably seated, the researcher and the assistant introduced themselves. The assistant was a graduate student trained in the administration of the D–KEFS tests under the supervision of the principal investigator. The instructions were read aloud, and the demographic sheet and PCRS were administered in a group setting. The second testing session took place at some comfortable and private place (usually the library or a laboratory room). The principal researcher and the assistant individually administered the D–KEFS tests. Standard administration process was followed; instructions were given in Urdu language already translated by the standard translation procedure. The principal researcher and the assistant scored the tests. After data collection, participants, staff members, and school principals were cordially thanked for their kind cooperation.

Statistical Analyses

Considering that the D–KEFS was administered in a culturally different country, and it is not evident that original American norms are applicable; the analyses were based on the test raw scores. For each of the executive measures, combined scores for the underlying fundamental cognitive skills and executive skills were calculated according the criteria described earlier in Method section.

Descriptive statistics of means and standard deviations were generated for the primary D–KEFS variables included in the study. Pearson correlations were calculated among all the EF measures (i.e., BNVA, CF, NSDFT, SDFT, FLS, CFVIT, VIE, and PSA as described in the Method section). A repeated-measure analysis of variance (ANOVA) was conducted on raw scores for the four EF tests to examine within-subject differences at the two levels of cognitive executive development (i.e., basic underlying cognitive abilities and executive abilities) and between-group differences in performance with gender and age as covariables. Pearson correlational analyses were finally conducted to discover any association in different dimensions of parent–child relationship (PCRS) and SES with EF scores.

Results

Table 2 presents the descriptive statistics for the EF measures. As expected, in general, standard deviations were about 20 to 30% of the mean scores for TMT and time measures of CWIT; score ranges were relatively large for DFT, CWIT (error score), and CST.

Correlations among different EF measures were statistically significant (see Table 3). Strength of the correlations was from high to low (.67–.11), suggesting commonality but also heterogeneity in the analyzed EFs. As expected, factors derived from the same tests were highly to moderately correlated with coefficients between .67 to .28 (e.g., correlation coefficients between BNVA–EF in TMT; NSDFT–SDFT in DFT; FLS–CFVIT, CFVIT–VIE, and FLS–VIE in CWIT were strongly correlated at $\alpha < .001$). Within the domain correlations were moderate, yet, significant at a stringent level ($\alpha < .001$; verbal ability as assessed from correlation between BNVA and FLS; cognitive flexibility as measured from TMT and CWIT).

Table 4 presents the means, standard deviations, and reliability coefficients of the PCRS and subscales. Cronbach's alpha for all the measures fairly supported the internal consistency of the instruments.

Gender Analysis Using Age as a Covariate

TMT. Raw scores were analyzed using a 2 × 2 ANOVA with condition (2 levels: BNVA and CF) as a within-subject factor, and gender (male or female) as between-subject factor. Age was covaried in this analysis as a continuous variable. After considering the assumption of sphericity to be met as indicated from nonsignificant chi-square value from Mauchly's test, the main effect of condition for raw scores was found to be significant, $F(1, 368) = 9.67$, $p < .005$, with greater completion time in switch condition ($M_{\text{time}} = 89.51$ s, $SD = 29.34$) than in combined number–letter sequence condition ($M = 44.76$ s, $SD = 11.63$).

Data analysis with raw scores showed a main effect of gender, $F(1, 365) = 29.55$, $p < .001$, with males showing better performance speed ($M_{\text{time}} = 61.04$ s, $SD = 19.65$) than females ($M_{\text{time}} = 71.68$ s, $SD = 20.21$) in both conditions. However, a significant interaction with gender was found, $F(1, 368) = 14.71$, $p < .001$, and larger gender differences at the BNVA level than at the CF level were observed. In addition, across both conditions age was a significant variable, $F(1, 368) = 6.90$, $p < .01$, in the raw score; with early adolescents performing at a slower speed ($M_{\text{time}} = 68$ s, $SD = 20.32$) than late adolescents ($M_{\text{time}} = 66.07$ s, $SD = 20.02$) across both conditions.

DFT. Raw scores for the number of correct generated designs in DFT were analyzed using a 2 × 2 ANOVA with condition

Table 2
Means (M) and Standard Deviations (SD) of D–KEFS Variables

D-KEFS Tests	D–KEFS variables	*M*	*SD*	Observed range
TMT (CT)	Condition 1: Visual scanning	29.66	7.84	13–49
	Condition 2: Number sequencing	44.57	13.48	17–78
	Condition 3: Letter sequencing	44.96	12.19	14–73
	Combined Conditions 2 & 3 (BNVA)	44.76	11.63	19–74
	Condition 4: Number–Letter switching (CF)	89.51	29.34	26–165
DFT (NCD)	Condition 1: Filled dots	7.16	3.19	0–22
	Condition 2: Empty dots	7.12	3.28	0–19
	Combined filled and empty dots (NSDFT)	7.09	2.93	0–20
	Condition 3: Switching, Filled/Empty dots (SDFT)	4.98	2.29	0–12
CWIT (CT)	Condition 1: Color naming	37.55	6.61	12–56
	Condition 2: Word reading	24.74	5.15	13–43
	Condition 3: Inhibition	67.69	14.20	41–103
	Condition 4: Inhibition/Switching	73.0	17.67	39–113
	Combined Conditions 1 & 2 (FLS)	62.29	10.62	36–93
	Composite Conditions 3 & 4 (CFVIT)	141.5	28.33	83–215
ES	Condition 3: Inhibition (Error)	5.57	3.97	0–19
	Condition 4: Inhibition/Switching (Error)	6.35	3.79	0–12
	Composite Conditions 3 & 4 error (VIE)	11.92	6.66	1–28
CST	Condition 1: Correct sort (CS)	5.20	2.57	0–13
	Condition 1: Description score (DS)	21.13	9.98	5–51
	Composite CS & DS (PSA)	26.33	12.48	6–64

Note. Underlined items in each test were used in the final analysis. D–KEFS = Delis–Kaplan Executive Function System; TMT = Trail Making Test; BNVA = Basic Numerical and Verbal Ability on TMT; CF = Cognitive Flexibility; DFT = Design Fluency Test; NCD = Number of Correct Design; NSDFT = Nonswitch Design Fluency Test score; SDFT = Switch Design Fluency Test score; CWIT = Color Word Interference Test; CT = Completion Time; FLS = Fundamental Linguistic Skill on CWIT; CFVIT = Cognitive Flexibility and Verbal Inhibition as measured by completion time on CWIT; ES = Error Score; VIE = Verbal Inhibition as measured by Error Score on CWIT; CST = Card Sorting Test; PSA = Problem-solving ability.

(NSDFT and SDFT) as a within-subject factor, gender (with two levels) as a between-subject factor, and age as a covaried factor. After finding the sphericity assumption to be met by a nonsignificant chi-square value from Mauchly's test, the main effect of condition was significant, $F(1, 369) = 19.61$, $p < .001$. Descriptive analysis revealed that all the participants generated the highest number of designs in NSDFT ($M = 7.17$, $SD = 2.93$) as compared to SDFT ($M = 4.96$, $SD = 2.29$).

When testing the between-subject effects, the main effect of gender was significant, $F(1, 367) = 6.803$, $p < .01$, for raw scores, as males outperformed females on all the conditions. According to tests of subject contrasts and related descriptive statistics, interactions of condition with gender, $F(1, 369 = 17.314$, $p < .001$, significantly showed greater gender differences in NSDFT. Condition also significantly interacted with age, $F(1, 369) = 8.583$, $p < .005$, showing greater age differences in the SDFT condition.

CWIT. The main dependent variable, as examined by the CWIT, was performance speed as measured in seconds. A repeated-measure 2 × 2 ANOVA was run on this data, with condition (FLS, inhibition and switching) as the within-subject factor, and gender (male or female) as the between-subject factor. Age as the continuous variable was covaried in the analysis. As revealed from the nonsignificant chi-square value from Mauchly's

Table 3
Correlation Among All Executive Functioning Measures

Measure	TMT BNVA	CF	DFT NSDFT	SDFT	FLS	CWIT CFVIT	VIE	CST PSA
BNVA	—	.67***	−.39***	−.19***	.30***	.22***	.11*	−.25***
CF		—	−.35***	−.17**	.20***	.22***	.11*	−.32***
NSDFT			—	.28***	−.18**	−.20***	−.13*	.23***
SDFT				—	−.15*	−.20***	−.18**	.25***
FLS					—	.61***	.31***	−.21***
CFVIT						—	.55***	−.20***
VIE							—	−.20***
PSA								—

Note. Time measures of TMT and CWIT are negatively correlated with the number of correct design in DFT and the number of correct sorts in CST. TMT = Trail Making Test; DFT = Design Fluency Test; CWIT = Color Word Interference Test; CST = Card Sorting Test; BNVA = Basic Numerical and Verbal Ability on TMT; CF = Cognitive Flexibility; NSDFT = Nonswitch Design Fluency Test score; SDFT = Switch Design Fluency Test score; FLS = Fundamental Linguistic Skill on CWIT; CFVIT = Cognitive Flexibility and Verbal Inhibition as measured by completion time on CWIT; VIE = Verbal Inhibition as measured by Error Score on CWIT; PSA = Problem-solving ability.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4
Means (M), Standard Deviations (SD), and Internal Consistency of Parent–Child Relationship Full Scale and Subscales

Scale/subscale	No. of items	*M*	*SD*	α
PCR	100	732.71	70.97	
Protecting	10	82.21	10.95	.66
Symbolic punishment[a]	10	59.18	14.32	.70
Rejecting[a]	10	36.51	11.45	.72
Object punishment[a]	10	38.87	12.85	.70
Demanding	10	72.32	12.74	.73
Indifferent[a]	10	40.99	11.45	.73
Symbolic reward	10	82.52	12.49	.85
Loving	10	83.15	12.86	.69
Object reward	10	66.34	14.27	.76
Neglecting[a]	10	41.24	12.15	.71

Note. $N = 370$. PCR = Parent–child relationship.
[a] Items were reversed-scored.

test, sphericity assumption was met, and the main effect of condition was found to be significant, $F(1, 366) = 28.30$, $p < .001$, for raw scores, as the performance speed was higher on FLS (combined color naming and word reading condition; $M = 62.69$s, $SD = 10.62$) in comparison to CFVIT (combined inhibition and switch condition; $M = 141.5$s, $SD = 28.33$). Among other tests of within-subject contrasts, interaction of condition with age and gender was not found to be significant.

Among tests of between-subject effects, gender was found to be a significant factor, $F(1, 366) = 5.78$, $p < .05$, with higher performance speed for females ($M = 99.57$ s, $SD = 37.86$) than for males ($M = 104.6$ s, $SD = 39.64$) across both conditions. Also, age was significant for raw scores, $F(1, 366) = 4.07$, $p < .05$, with late adolescents ($M = 99.85$ s, $SD = 38.02$) showing better performance speed than early adolescents ($M = 102.85$ s, $SD = 39.23$) across both conditions (evident from no significant interaction with condition).

CST. The composite score of the total number of free correct sorts and the description score of free correct sorts was evaluated by analyzing a between-group 2 × 2 ANOVA effect of age (early adolescents and late adolescents) and gender (two levels). This analysis showed a significant effect on gender, $F(1, 349) = 5.524$, $p < .05$. In general, females performed less efficiently ($M = 24.78$, $SD = 11.23$) than males ($M = 28.05$, $SD = 13.22$). However, analysis revealed no significant effect of age for raw scores. Interaction between age and gender also was not statistically significant.

Perceived Parent–Child Relationships and Performance on EF Measures

Pearson's correlational analyses were carried out for the association between full-scale and subscale scores of the PCRS, and the scores of different executive functioning measures. Table 5 indicates that the full-scale PCRS score is significantly correlated with performances on CWIT and CST measuring CFVIT, VIE, and PSA. Further analyses of the association of subscales of the parent–child relationship with D–KEFS tests indicated that Neglecting was the primary predictor of all the executive functioning measures. Correlation coefficients also indicated a significant association between performance on the CWIT and different subscales of the PCRS including Protection, Rejection, Object Punishment, Loving, and Neglecting. Analyses also revealed significant association of PSA with Protection, Rejection, Indifferent Behavior, and Neglecting.

Correlation coefficients also were calculated for the association of demographic variables with EF measures. SES and parent education were significantly associated with all the measures of

Table 5
Correlation Between Cognitive Measures, Demographics, and Parent–Child Relationships

Study Variables	TMT		DFT			CWIT		CST
	BNVA	ECF	NSDFT	SDFT	FLS	CFVIT	VIE	PSA
Parent education	−.03	−.04	.15**	.15**	−.18**	−.15**	−.10	.23***
Parent occupation	−.05	.01	.05	.15**	−.01	−.02	−.04	.10
Family income	.01	−.06	.04	.16**	−.12*	−.12*	−.10	.09
SES	−.03	.01	.11*	.19***	−.14*	−.13*	−.11*	.18**
PCR	−.03	−.02	.01	.07	−.09	−.12*	−.20***	.12*
Protection	−.01	−.08	.05	.10	−.03	−.03	−.11*	.12*
Symbolic punishment[a]	.14*	.08	−.09	−.08	.08	.03	.04	−.01
Rejection[a]	.02	.07	−.09	−.05	.08	.14*	.13*	−.20***
Object punishment[a]	.01	.02	−.04	−.06	.14*	.14*	.14*	−.09
Demanding	−.05	−.06	−.03	.04	.03	−.02	−.02	.03
Indifferent[a]	.10	.12*	−.08	−.07	.02	.03	.03	−.20***
Symbolic reward	−.08	.004	.05	.01	−.05	.01	−.07	.04
Loving	.01	−.07	.03	.02	−.04	−.10	−.13*	.04
Object reward	.03	.01	.07	.02	−.04	−.06	−.05	.02
Neglecting[a]	.12*	.26***	−.18**	−.15**	.13*	.13*	.23***	−.31***

Note. Underlined values are significant correlations. TMT = Trail Making Test; DFT = Design Fluency Test; CWIT = Color Word Interference Test; CST = Card Sorting Test; BNVA = Basic Numerical and Verbal Ability on TMT; ECF = Executive Cognitive Flexibility; NSDFT = Nonswitch Design Fluency Test score; SDFT = Switch Design Fluency Test score; FLS = Fundamental Linguistic Skill on CWIT; CFVIT = Cognitive Flexibility and Verbal Inhibition as measured by completion time on CWIT; VIE = Verbal Inhibition as measured by Error Score on CWIT; PSA = Problem-solving ability; SES = socioeconomic status; PCR = Parent–child relationship.
[a] Items were reversed-scored.
* $p < .05$. ** $p < .01$. ** $p < .001$.

executive abilities and underlying basic cognitive abilities except with BNVA and CF as assessed from TMT. Analyses also indicated a significant association of parent occupation with SDFT; as well as a correlation between family income with SDFT and time measures of CWIT that is, FLS and CFVIT.

Discussion

This study presents a comprehensive estimate of different executive skills of Pakistani adolescents from a South Asian background. As we do not have any indigenous scale for measuring EF in this population group, the D–KEFS tests were used to estimate their level of EF. Moreover, we do not have any normative data for D–KEFS from Pakistan; therefore the raw scores were analyzed. EF tests of D–KEFS battery as used in this study, measured executive skills by requiring children to switch between numbers and letters in the TMT, generate new designs in the DFT, inhibit a dominant response in favor of a novel response in CWIT, and sort cards in the CST. Of course, it is inevitably impossible to be sure about the psychometric equivalence of these tasks across cultures.

Despite the theoretical basis of association across aspects of EF, the degree of correlations was high to low. In general, high correlations were detected for factors from the same tests and moderate correlations were observed from the same domains (e.g., verbal ability and cognitive flexibility) assessed with different tests: TMT and CWIT. Moderate correlations were also identified for executive measures as taped from processing speed (.30–.20; among BNVA, FLS, CF, and CFVIT). Low correlations were identified only for the error scores on CWIT with other executive measures (particularly with TMT and DFT). However, this heterogeneity in EF measures pinpoints the multidimensional nature of EF, further supporting the use of more than one test for the comprehensive understanding of EF.

Age and Gender Related Differences

We examined the age-related changes in processing speed, creativity, inhibition, and problem-solving ability from early to late adolescence. Linear age-related improvement was evident in the raw scores for TMT and CWIT across both conditions and only for DFT across the switch condition. Age-related improvement in raw scores showed parallels between improvement in cognitive performance as observed in the current study and brain maturation studies cited in the earlier section (e.g., Anderson et al., 2001; Kramer, 2014; Spear, 2000). In contrast, problem-solving ability, as measured from scores on CST, showed relatively low scores and stable results for early and late adolescents. This most likely indicates relatively early maturation of this skill, while being more susceptible to cultural influences.

Our study also compared the performance of adolescents between genders. The main effect of gender was significant on performance in all the selected tests. Males outperformed females on TMT, DFT, and CST. As TMT, DFT, and CST require visual, numerical, and perceptual skills the results were consistent with previous findings suggesting superior visual-spatial abilities in males (Benbow & Stanley, 1983; Weiss, Kemmler, Deisenhammer, Fleischhacker, & Delazer, 2003). On the other hand, females showed a better response rate on the CWIT. A basic cognitive ability contributing to this test is the fundamental linguistic skill; these results are in line with earlier studies of verbal ability favoring females (Burton, Henninger, & Hafetz, 2005; Chipman & Kimura, 1998; Delis, Kramer, Kaplan, & Ober, 1987; Kolb & Whishaw, 2001; Weiss et al., 2003). In addition, better performance of females on CWIT—a task of attentional control and processing speed—is in agreement with gender specific maturational changes in brain development (Giedd et al., 1996). Differential hormonal processes or different experiences may be responsible for these varied brain maturational changes and ultimately gender differences in EF. Future research is needed to delineate the gender specific trajectories and domain specific trajectories of EF development through longitudinal studies.

Association Between Perceived Parent–Child Relationships and EF

One of the goals of this study was to pinpoint the association between EF test scores and perceived parent–child relationships. Early theoretical reviews (e.g., Kagan, 1999) as well correlational studies (Portes, Cuentas, & Zady, 2000) have documented the influence of parent–child relationships on cognitive development, particularly on EF in Western children. Our findings clearly demonstrate for the first time that this link also is found in South Asian adolescents. These findings agree with many other studies discussed in the Introduction section (e.g., Carlson, 2003; Schroeder & Kelley, 2009). This result can be particularly important given the cross-cultural differences between the Asian–U.S. cultures in parenting and family environment (Nomura, Noguchi, Saito, & Tezuka, 1995).

It is important to emphasize that although there is a significant amount of research demonstrating the negative effects of serious parental neglect collected in Western countries, the present study represents an extension of these findings to a nonclinical non-Western sample.

The findings from the current study extend the existing literature on the link between parent–child relationship and EF by simultaneously considering the multiple dimensions of parent–child relationships and EF measures. We found that parent–child relationships have significant correlations with cognitive flexibility, inhibition, and problem-solving ability as measured from CWIT and CST raw scores, respectively. Correlations with the different subscales suggest that the association is not driven by only one dimension of the parent–child relationship, but rather by multiple dimensions, including: protection, rejection, object punishment, indifferent behavior, loving, and neglecting. These dimensions are consistently associated with cognitive flexibility, verbal inhibition, and problem-solving ability. Furthermore, although completion time was taken as the main dependent variable for the assessment of inhibition, it seems that committing errors while inhibiting an over learned response, representing difficulty in inhibition; also provide a worthwhile additional measure of inhibition. Inspection of Table 5 indicates that correlation coefficients for error measure are larger and range from .11 to .23 with strongest correlation with neglect and PCR, while comparable coefficients for time measures are smaller and range from .12 to .14. In addition, it is important to note that correlation coefficients of different PCR subscales with problem-solving ability are stronger than all the other correlation coefficients with other executive functioning measures; ultimately, indicating that this ability is more sensitive to the quality of parent–child relationships.

Specific analysis of different dimensions of parent–child relationship revealed that Neglecting shows the most robust correlations with all the EF measures. Although our findings are consistent with a large body of research (Andersen, 2003; Beers & De Bellis, 2002; Bremner & Vermetten, 2001; De Bellis, 2005) documenting the detrimental effects of neglect on EF development in Western samples; to the best of our knowledge, this is the first study that assesses the relationship between neglect and EF in a non-Western sample from a developing country such as Pakistan. In addition, this current sample is not restricted to an abnormal population; rather it represents a normal functioning population. These findings are consistent with our predictions based on previous studies (e.g., Glaser, 2000) that described lower levels of executive skills in neglected children as compared to normal children. Results of the study support the postulated implications of parent–child relationships on continuously developing prefrontal cortex during adolescence.

Association With SES and Education

Another goal of the current study was to assess the association of EF with SES based on three variables including parents' education, occupation, and family income (McLoyd, 1998). Analysis revealed overall SES and parent's education to be the positive predictors of EF as assessed by performance on all the tests except on TMT. Although, the findings are consistent with diverse studies from Western culture (Klenberg et al., 2001; Sarsour et al., 2011), the findings are particularly important given the cross-cultural differences in economic conditions and literacy rate in Pakistan as compared to developed Western countries. Second, important role of parent's education is commonly described to facilitate verbal cognitive skills in many studies (e.g., Hoff, 2003; Hoff-Ginsberg, 1991), but many of the EF in current study are assessed from tasks (e.g., TMT, DFT, and CST) requiring visual, perceptual, and spatial skills. In addition, in agreement with the predictions based on Lynn and Vanhanen (2002, 2006), the current study found family income to be significantly correlated with performance on SDFT, FLS, and CFVIT measuring creativity and flexibility of thinking.

Strengths, Limitations, and Implications

The present research has several methodological strengths over previous studies. First, EF was measured using a sound and reliable test battery as compared to general cognitive tests as frequently used in past studies. Second, adolescent's self-reports of parent–child relationships are of great importance to understand parent–child relationships from the adolescent's perspective (e.g., Schaefer, 1965; cf. Doyle et al., 2004). It is essential to consider this perspective for a proper analysis as this has been frequently overlooked in the previous studies. Finally, the present study advances the existing literature on parenting—EF associations by considering multiple aspects of parent–child relationship quality, as suggested by Rothbaum and Weisz (1994) in their meta-analytic report.

However, a cross-sectional study does not allow us to make causational association between parenting styles and EF. It is difficult to interpret whether poor quality parent–child relationships, and particularly neglecting, causally interfered with EF development or poorly developed executive skills were responsible for problems in parent–child relationships. Noteworthy, Blair, Raver, and Berry (2014) in a longitudinal study using a sample of 1,292 children between the ages of 36 and 60 months found that higher quality parenting predicted a more positive gain in EF at 60 months.

The generalization of our results should be cautious. Our sample was taken from the fifth biggest cosmopolitan city of South Asia; additional information from other non-Western countries, smaller cities, and rural areas should be collected. Finally, our study does not directly address the comparison of executive skills across different cultures; indeed, that is a question that goes beyond the aim of our research.

Another concern of this study refers to the absence of norms for neuropsychological tests in general and EF in particular in Pakistan. However, considering the lack of a normative/comparison group, current results may be interpreted as preliminary normative EF scores for our Pakistani sample. Nonetheless, much more additional information with other age ranges and populations taken from other environments is required. The collection of neuropsychological test normative scores in non-Western societies is strongly required in our contemporary world. Toward the future it also would be important to investigate whether EF measures can be combined to obtain a summary score for EF.

The study presents a comprehensive analysis of executive skills of adolescents from a South Asian developing country. This population seems to be of great interest because very limited research is conducted on this population previously. Due to this, generalization from Western studies appears, of course, inappropriate due to different cultural experiences. Also, the findings highlight specific aspects of executive functioning that are most sensitive to cultural variation such as problem-solving ability. These findings would provide a guide for developing a culturally sensitive assessment tool for the evaluation of executive functioning of a South Asian population. Also, as the study integrates the use of a validated measure of EF in a novel cultural context, the paper contributes to the literature by providing evidence for an important relationship between parent–child interaction and EF in a non-Western population. Therefore, the study emphasizes the need to study EF abilities in non-Western cultures through an indigenous measurement tool.

In summary, this study highlights the importance of developing an indigenous measurement tool for the assessment of executive function in this population group. Findings emphasize and further support the impact of the family conditions on the EF development during adolescence. It is interesting that some gender differences in executive skills were observed, sometimes favoring males in EF relying on visual, spatial, and numerical abilities, but also favoring females in executive skills relying on verbal abilities. Some specific elements of parent–child relationship including, protection, rejection, neglect, loving, and objective reward were found to be important determinants of EF. Finally, SES and parents' education were found to be important predictors of creativity, inhibition, and problem-solving ability.

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