

ORIGINAL ARTICLE

Executive Functioning Across the Transition to Kindergarten: Links With Social and Academic Outcomes in Early Childhood

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ABSTRACT

The current project investigates the longitudinal relations of executive functioning (EF) at the beginning of pre-kindergarten, and outcomes of (mal)adjustment both at the end of pre-kindergarten and beginning of the kindergarten. To examine this aim, a secondary analysis was conducted using a large, primarily low-income and under-represented early childhood sample ($N = 476$, $M = 52.8$ months old, 47.3% female, 60.8% Black and Hispanic/Latinx). Data were analyzed using confirmatory factor analyses and longitudinal structural equation modelling. Results demonstrated that an affective conceptualization of EF predicted increases in social competence across the pre-kindergarten year. When examining effects from the beginning of pre-kindergarten to kindergarten, a traditional, non-affective, conceptualization of EF predicted increases in academic achievement whereas affective EF skills predicted decreases in aggression. Importantly, conclusions are interpreted with caution given measurement limitations. Results from the current study provide insight regarding the development of EF during early childhood and the transition from preschool to kindergarten for a marginalized and under-resourced population.

1 | Theoretical Considerations

The development of self-regulation is a critical milestone as it plays a foundational role in an individual's ability to engage in goal-directed behavior. Executive functioning (EF), an important aspect of self-regulation, is conceptualized as a set of top-down neurocognitive processes involved in the control of thought, emotion, and behavior (Zelazo and Carlson 2012). EF is often operationalized as a hierarchical construct that comprises three distinct but interrelated factors—inhibitory control, working memory, and cognitive flexibility (Di Norcia et al. 2015; Miyake et al. 2000; Zelazo, Blair, and Willoughby 2016). Inhibitory control is characterized by the ability to deliberately override a dominant or prepotent response (Di Norcia et al. 2015; Miyake et al. 2000). Working memory is defined as the ability to temporarily store

and mentally manipulate information (Di Norcia et al. 2015). Cognitive flexibility, also known as set-shifting, refers to the ability to shift behaviors and cognitions based on contextual demands (Miyake et al. 2000).

As the EF literature advances, a broader conceptualization of EF has been proposed that accounts for cool EF and hot EF (Zelazo and Carlson 2012). Indicators of cool EF are often viewed as traditional components of EF and refer to top-down executive control processes in tasks with limited emotional or motivational salience (Welsh and Peterson 2014; Zelazo and Carlson 2012), whereas hot EF is characterized by the use of EF skills in emotionally or motivationally salient tasks (Welsh and Peterson 2014; Zelazo and Carlson 2012). Hot and cool EF are conceptualized to

be closely related, though ultimately distinct aspects of self-regulation (Welsh and Peterson 2014). However, some posit that hot and cool EF operate as a unitary construct in early childhood and become differentiated across development (Garon, Bryson, and Smith 2008). These discrepant findings may be because the difference between hot and cool EF is dimensional in nature (Hendry, Jones, and Charman 2016). As such, rather than purely hot or cool tasks, measures may instead tap into both forms of EF to differing degrees. The current project acknowledges this complex relation and tested the possibility of a one factor model.

2 | Outcomes of Executive Functioning

2.1 | Executive Functioning and Academic Achievement

There is a robust literature to support the relation between traditional EF and academic achievement (Garon, Bryson, and Smith 2008; Zelazo, Blair, and Willoughby 2016). Traditional EF skills promote academic achievement by supporting learning-related behaviors (e.g., higher engagement with class lessons/activities) and allowing a child to better orient toward learning materials (Brock et al. 2009; Denham et al. 2012; Willoughby et al. 2011). Indeed, Nesbitt, Farran, and Fuhs (2015) demonstrated that cool EF skills at the start of pre-kindergarten predicted learning behaviors, which ultimately led to gains in both mathematics and literacy. A meta-analysis using primarily cool measures of EF demonstrated that specific EF components uniquely predict academic achievement (Spiegel et al. 2021). For instance, working memory may be crucial as children learn to decode simple words (Spiegel et al. 2021).

Research is mixed regarding the extent affective EF skills influence academic achievement. Theoretically, academic success may rely on affective components of EF given the importance of down-regulating emotions that interfere with learning and attending to relevant material (Brock et al. 2009). Thus, deficits in affective EF may put children at risk for increased dysregulation that interferes with learning and academic performance. Backer-Grøndahl, Nærde, and Idsoe (2018) demonstrated that hot EF in early childhood indirectly predicts school performance via its effect on externalizing behaviors. Although hot EF also had a small direct effect on academic achievement in this sample, a stronger association was found between cool EF and academic performance. This corresponds with prior work that suggests traditional EF is more robustly linked to academic success relative to affective EF skills in early childhood (Brock et al. 2009; Willoughby et al. 2011).

2.2 | Executive Functioning, Social Competence, and Aggression

Beyond school performance, EF in early childhood also predicts adaptive social functioning, like social competence (Rademacher and Koglin 2018; Zelazo, Blair, and Willoughby 2016). Given that affective EF is inherently related to self-regulation in emotionally/motivationally salient situations, it is thought to be more tightly linked with socio-emotional outcomes relative to traditional EF (Backer-Grøndahl, Nærde, and Idsoe 2018;

Brock et al. 2009; Di Norcia et al. 2015; Willoughby et al. 2011). Social competence is characterized by cooperation, assertiveness, positive social engagement, and effective communication with peers (Denham et al. 2009; McKown et al. 2009). Gains in affective EF may foster the development of these skills and influence social competence through the coordination of higher-order cognitive processes that are necessary for social problem-solving (Riggs et al. 2006).

High levels of EF in early childhood have been linked to reduced general indicators of externalizing behaviors, but specific impacts on aggression are unknown (Romero-López et al. 2018). Therefore, the current study is also interested in the affective components of EF and its links with aggression. Aggression is defined as a range of behaviors intended to harm an individual (Crick, Casas, and Mosher 1997). Inhibitory control may play a particularly important role in the link between hot EF and aggression. Prior work indicates that affective inhibitory control may allow children to suppress dominant responses (e.g., aggression) for sub-dominant behaviors that allow for social cohesion and align with social expectations (Di Norcia et al. 2015; Romero-López et al. 2018). Indeed, prior work demonstrated that hot, but not cool inhibitory control was positively related to social competence and negatively related to aggression (Di Norcia et al. 2015). Affective cognitive flexibility is critical in the development of adaptive social behaviors, whereby shifting focus away from negative or stressful stimuli may allow for positive and adaptive responses (Eisenberg, Smith, and Spinrad 2004). Although traditional EF may also play a role in promoting social competence and reducing aggression, it is expected that when accounting for affective components of EF, this effect will be minimized (Backer-Grøndahl, Nærde, and Idsoe 2018; Brock et al. 2009; Di Norcia et al. 2015).

3 | Current Study

The current study aims to examine whether traditional and affective EF skills differentially predict academic and social outcomes across the transition from pre-kindergarten to kindergarten. Prior work has often examined these relations in older children (c.f. Willoughby et al. 2011), however, early childhood is a critical developmental period to assess these effects given the rapid gains in EF skills at this age and the lasting effects of EF on future development (Garon, Bryson, and Smith 2008; Zelazo, Blair, and Willoughby 2016). Not only may this study expand the EF literature through a developmental lens, but it is also unique in its exploration of both adaptive and maladaptive outcomes in the same model. Examining adaptive and maladaptive outcomes in turn has the potential to inform early protective and risk factors in young children.

This study was unique in examining effects both within the pre-kindergarten year and across the transition to kindergarten. It was hypothesized that traditional EF skills at the beginning of pre-kindergarten (Time 1) will uniquely predict higher levels of academic achievement at the end of pre-kindergarten (Time 2) and at the beginning of kindergarten (Time 3), and affective EF skills at Time 1 will uniquely predict lower levels of aggression and higher levels of social competence at Time 2 and Time 3. A secondary analysis examining an early childhood sample was

conducted to assess these hypotheses using multiple methods including behavioral assessments and teacher reports.

4 | Method

4.1 | Participants

This secondary analysis used publicly available data (via Inter-university Consortium for Political and Social Research at the University of Michigan), collected in the Efficacy Trial of Second Step Early Learning (SSEL) Program (Upshur and Wenz-Gross 2020). Participants were recruited from 63 preschool classrooms within 13 childcare centers (6 Head Start sites and 7 community preschool programs) in Worcester County, Massachusetts. The original study examined the effects of a socio-emotional learning curriculum on child development, and children were randomly assigned to the intervention or control group based on their classroom. To mitigate the potential effects of the intervention on analyses, the current study only included data from the control group. Of this sub-sample ($N = 476$; 47.3% female; M age at Time 1 = 52.8 months, $SD = 4.09$ months), participants were racially/ethnically diverse—0.6% Asian/Pacific Islander, 22.1% Black American, 38.7% Hispanic/Latinx, 8.6% Multiracial, 23.7% Non-Hispanic White, and 6.3% missing. The majority of participants attended a Head Start program (55%) and generally came from a low socioeconomic background with regards to parent education (44.7% high school or less, 40.6% some college or 2-year degree, 11.1% college graduate or more, and 3.6% missing) and household income (51.1%: <\$19,999, 23.9%: \$20,000–\$29,999, 11.1%: \$30,000–\$39,999, 4.6%: \$40,000–\$49,999, 5.3%: >\$50,000, and 4% missing). Both parental education and income were operationalized on an ordinal scale (e.g., 1 = < \$19,999; 2 = \$20,000–\$29,999). Standardized values were calculated for each variable and used to create a mean composite for socioeconomic status.

4.2 | Procedure

Data collection occurred across three time points—during children’s pre-kindergarten year in the fall (Time 1) and spring (Time 2), and in the fall of kindergarten (Time 3). Data were collected across four cohorts (2013–2017) in which each cohort was followed for 1 year. For recruitment, consent forms were distributed to English- and/or Spanish-speaking parents at Time 1 (recruitment rates ranged from 88% to 91% across classrooms). School-based behavioral assessments were administered by trained research assistants (for details see Upshur et al. 2019).

4.3 | Measures

4.3.1 | Traditional Components of Executive Functioning

4.3.1.1 | Working Memory. The Backward Digit Span task (Davis and Pratt 1995) is a measure of traditional working memory that was administered to participants by research assistants at Time 1. Children were orally given a series of numbers and then asked to recite them in the reverse order. Total scores

were calculated based on the highest string of numbers correctly repeated in the reverse order and ranged from 1 to 5 (score of 1 refers to child unable to correctly repeat two digits). With regards to psychometrics, this task has been validated in several preschool samples (Carlson 2005; Hamre et al. 2014; Müller, Kerns, and Konkin 2012) and has demonstrated adequate reliability (e.g., Cronbach’s $\alpha = 0.77$; Lipsey et al. 2017).

The Children’s Size-Ordering Task (CSOT; McInerney, Hrabok, and Kerns 2005) is a behavioral assessment that was used to assess nonverbal working memory at Time 1. In this task, the examiner presents a picture and reads aloud a list of common objects. The examiner then covers the picture and asks the child to visualize the objects and repeat the list of objects ordered by size. The total possible score ranged from 0 to 42 and was based on the number of correctly ordered word pairs the child stated. Prior work indicates that the CSOT demonstrates adequate internal consistency in preschoolers (e.g., Cronbach’s $\alpha = 0.69$; Tillman et al. 2011), and is significantly related to other measures of working memory (Lerner and Lonigan 2014). Given that the CSOT and Backward Digit Span were significantly correlated with each other ($r = 0.30$, $p < 0.001$), the overall working memory score was operationalized as a standardized composite of these total scores.

4.3.1.2 | Inhibitory Control. The Head-Toes-Knees-Shoulders task (HTKS; McClelland et al. 2007; Ponitz et al. 2008) was used as a behavioral measure of traditional inhibitory control. The HTKS was originally designed as a general assessment of overall EF in young children (McClelland et al. 2007). Since its conception, subsequent work suggests that this task primarily taps into inhibitory control (Traverso et al. 2022). In this task, participants were instructed to do the opposite of what they are told (e.g., to touch their toes when instructed to touch their head). Scores on each item ranged from 0 to 2 and total scores were calculated by summing the scores across all items, with a maximum total of 60. The HTKS has demonstrated internal consistency in early childhood (e.g., Traverso et al. 2022). Due to the available data, the current study could not calculate a reliability coefficient for this sample, though results from the full sample in the original intervention project (Wenz-Gross et al. 2018) demonstrated internal consistency (Cronbach’s $\alpha = 0.84$).

4.3.1.3 | Cognitive Flexibility. The Dimensional Change Card Sort (DCCS; Zelazo 2006) task is a behavioral assessment of traditional cognitive flexibility which was administered at Time 1. In this task, the participant is presented with two sorting trays that vary along two dimensions (i.e., color and shape). First, the child is asked to sort a series of bivalent cards along a single dimension (i.e., color). Next, the child is told that the rules of the game have changed, and they must now sort according to the second dimension (i.e., shape). Lastly, the child was required to alternate between sorting rules (i.e., sorting by color or shape). Each trial included multiple items and participants progressed to the next trial if they answered a certain number of items correctly. Total scores were based on how many trials the children progressed through and ranged from 0 to 3. Overall, the DCCS has been validated across many preschool samples (for a review see Doebel and Zelazo 2015), and prior work has demonstrated it to have adequate internal consistency (e.g., Cronbach’s $\alpha = 0.92$; Caughy et al. 2013).

4.3.2 | Affective Components of Executive Functioning

4.3.2.1 | Inhibitory Control and Cognitive Flexibility.

The Preschool Self-Regulation Assessment–Assessor’s Report (PSRA-AR; Smith-Donald et al. 2007) is a measure that was adapted from the Leiter-R Social-Emotional Rating Scale (Roid and Miller 1997) and the Disruptive Behavior-Diagnostic Observation Schedule coding system (DB-DOS; Wakschlag et al. 2005). The measure is a global report of the child’s behavior during the assessment and was completed at Time 1 following the administration of the behavioral assessments in the original study. In its entirety, the PSRA-AR is a 28-item measure with three distinct subscales—attentional control, impulse control, and positive engagement/emotionality. Given that this study is interested in aspects of EF, only the first two subscales were used in primary analyses. Based on an examination of the items, attentional control, and impulse control were used to operationalize affective features of cognitive flexibility and inhibitory control, respectively.

Research assistants used a 4-point Likert scale to rate participants across five cognitive flexibility items (e.g., “sustains concentration; willing to try repetitive task”) and six inhibitory control items (e.g., “lets examiner finish before starting task; does not interrupt”). Total scores were created by calculating a mean composite for each subscale. The PSRA-AR is adapted from assessments of social-emotional behaviors and self-regulation, which suggests that affect may be built into the measure. Although reliability statistics are unavailable for the current subsample, the measure has been validated across various preschool samples (Raver et al. 2013; Upshur et al. 2019) and has demonstrated good internal consistency (Cronbach’s $\alpha = 0.92$; Raver et al. 2013).

4.3.3 | Academic Achievement

Math and literacy skills were assessed at Time 1 and 2 using the Woodcock-Johnson Tests of Achievement III (WJ-III; McGrew et al. 2007; Woodcock et al. 2001). Research assistants administered the WJ-III Applied Problems subtest to assess pre-math skills, in which participants were required to solve a series of word problems. Literacy skills were measured using the Letter-Word Identification subtest in which children identified individual letters and increasingly complex words. Standard scores were calculated across subtests and academic achievement was operationalized as a mean composite of both math and literacy skills. Both the Applied Problems (e.g., Cronbach’s $\alpha s = 0.80$ – 0.92 ; Son et al. 2019) and Letter-Word Identification (e.g., Cronbach’s $\alpha s = 0.85$ – 0.90 ; Son et al. 2019) subtests have demonstrated adequate reliability.

Given that the WJ-III was only administered in pre-kindergarten in the original study, academic achievement in kindergarten was operationalized using teacher-report on the Academic Competence subscale within the Social Skills Improvement System (SSIS; Gresham and Elliott 2008). The SSIS is a revision of the Social Skills Rating System (SSRS; Gresham and Elliott 1990) and is adapted for use in preschool samples. Teachers rated children’s academic achievement across 7 items on a 5-point Likert scale (0 = *Lowest 10%*; 1 = *Next Lowest 20%*; 2 = *Middle 40%*; 3 = *Next*

Highest 20%; 4 = *Highest 10%*). Items assessed children’s math and literacy skills (4 items; e.g., “In reading, how does this student compare with other students”), overall academic performance (1 item), academic motivation (1 item) and general intelligence (1 item). Total scores were operationalized as a standardized score with a mean of 100 and a standard deviation of 15. Despite the difference between the content of this subscale and the behavioral assessments, analyses indicated significant correlations with this study’s measures at Time 1 ($r = 0.50$, $p < 0.001$) and Time 2 ($r = 0.53$, $p < 0.001$), suggesting they are comparable.

4.3.4 | Social Competence and Aggression

Teacher-report on the SSIS (Gresham and Elliott 2008) was used as a measure of social competence and aggression (i.e., use of aggressive behavior) at Time 1, 2, and 3. Given that social competence is a multi-faceted construct characterized by a range of behaviors, this study operationalized it as a composite using 27 items across the following subscales—Communication (7 items; e.g., “Takes turn in conversations”), Cooperation (6 items; e.g., “Follows classroom rules”), Assertion (7 items; e.g., “Stands up for herself/himself when treated unfairly”), and Engagement (7 items; e.g., “Interacts well with other children”). Teachers rated children along a 4-point Likert Scale (0 = *Never*, 1 = *Seldom*, 2 = *Often*, 3 = *Almost Always*). Total scores were calculated as a raw sum composite across subscales. With regards to aggression, five items (e.g., “Is aggressive towards people and objects”) were used from the Bullying subscale. Bullying is often defined as repetitive instances of aggression in which there is a power imbalance between the aggressor and victim (Olweus and Limber 2010). Given that power imbalance and repetition were not mentioned in the SSIS operationalization, the current study conceptualized this subscale as aggression, though its form (i.e., relational and physical) and function (i.e., reactive and proactive) were ambiguous. Total scores were calculated by creating a sum composite across items. Given that individual items in the original dataset were not available, internal consistency for aggression and social competence were unable to be calculated in the current study. That said, the overall SSIS measure demonstrated excellent internal consistency (Cronbach’s $\alpha = 0.97$) when examined in a preschool sample (Frey, Elliott, and Gresham 2011).

4.4 | Data Analysis

All models were analyzed in Mplus version 8.8 (Muthén and Muthén, 1998–2022). Preliminary analyses were run to examine descriptive statistics and correlations among variables. Non-normality was assessed via skew and kurtosis values, whereby non-normality was indicated by absolute values greater than 3 and 10, respectively (Kline 2016). Analyses were also performed to determine the nature of missing data. Preliminary analyses also included running a series of confirmatory factor analyses to determine the factor structure of EF. Details of these analyses may be found in the [Supporting Information](#).

Longitudinal structural equation model (SEM) analyses were run to assess the effects of traditional versus affective EF skills on academic achievement, social competence, and aggression. Two models were tested as follows: (1) effects from Time 1 to Time 2

TABLE 1 | Descriptive statistics of primary variables.

	N	Mean	Standard deviation	Range
Children's size ordering task T1	344	1.88	2.73	0–10.47
Backward digit span T1	470	1.10	0.32	1.00–2.35
Head toes knees shoulders T1	474	7.66	12.10	0–45.00
Dimensional change card sort T1	345	1.44	0.62	0–3.00
PSRA-impulse control T1	462	2.67	0.433	1.24–3.00
PSRA-attentional control T1	462	2.25	0.67	0.23–3.00
Communication T2	419	15.17	3.28	5.26–21.00
Cooperation T2	419	12.42	3.27	5–18.00
Assertion T2	419	12.87	3.16	3.26–21.00
Engagement T2	418	14.47	3.41	5–21.00
Social competence T2	418	54.93	13.12	18.52–81.00
Aggression T2	418	1.85	2.38	0–9.00
WJ letter-word T2	408	96.88	11.56	63–133.65
WJ applied problems T2	408	100.80	10.82	67.83–133.72
Communication T3	250	14.68	3.80	3.28–21
Cooperation T3	250	11.10	4.08	0–18
Assertion T3	250	12.07	3.44	1.75–21
Engagement T3	250	14.50	3.56	3.82–21
Social competence T3	250	52.35	14.88	8.85–81
Aggression T3	250	1.32	2.44	0–13
Academic competence T3	249	95.49	14.02	63–122

Note: Skew (range = -1.56 to 2.49) and kurtosis (range = -0.77 to 7.13) statistics indicate that the non-normality of data was not a concern. Abbreviations: PSRA = preschool self-regulation assessment, T1 = Time 1, T2 = Time 2, T3 = Time 3, WJ = Woodcock-Johnson IV.

and (2) effects from Time 1 to Time 3. To ensure the robustness of hypothesized paths, analyses also tested non-hypothesized effects (e.g., affective components of EF predicting academic achievement). Overall model fit was tested using the likelihood ratio χ^2 , where $p > 0.05$ indicates acceptable model fit. Analyses also relied on alternative relative goodness-of-fit indices (Browne and Cudeck 1992), including the comparative fit index (CFI; >0.90 = adequate fit, >0.95 = good fit), the standardized root-mean-square residual (SRMR; <0.08 = adequate fit, <0.05 = good fit; Hu and Bentler 1998), and the root mean square error of approximation (RMSEA; <0.08 = adequate fit, <0.05 = good fit; Steiger 1990). The impact of covariates was determined using bivariate correlations to assess possible effects of gender, age, and SES. Covariates were included in the model if correlations revealed $r > 0.30$ with any of the outcome variables (Cohen 1988).

5 | Results

5.1 | Preliminary Results

First, descriptive statistics for variables at Time 1, 2, and 3 were calculated and may be found in Table 1. Across variables, outliers were rare (range = 0%–2.34%) and were all adjusted by being set to three standard deviations above/below the mean

value. Inter-correlations across study variables were calculated and are presented in Table 2. When examining for possible covariates, results demonstrated small correlations ($r < 0.30$) between gender, SES, and age, and Time 2/Time 3 outcome variables. Thus, in line with a priori plans, these variables were not controlled for in analyses.

Data were missing for 12% of the participants from Time 1 to 2. One-way ANOVAs showed no statistical difference for missing cases in gender, SES, age, race, program (e.g., Head Start or community), EF, academic achievement, or aggression [F range = 0.002 – 3.98 , p range = 0.06 – 0.97]. However, analyses indicated missing cases did significantly differ for initial levels of communication [F (1,465) = 3.98 , $p = 0.047$, $\eta^2 = 0.01$], engagement [F (1,465) = 5.25 , $p = 0.02$, $\eta^2 = 0.01$], and cooperation [F (1,466) = 6.37 , $p = 0.01$, $\eta^2 = 0.01$], in which lower scores were associated with attrition. The magnitude of these effects is small, suggesting bias associated with these differences was low (Cohen 1988). As such, it was deemed acceptable to accommodate missing data within the sample using full information maximum likelihood (FIML) procedures, thus allowing all cases to be included in analyses (Enders and Bandalos 2001; Little 2013). A total of 47.7% of participants were missing data from Time 1 to 3. Missingness from Time 1 to Time 3 was not significantly related to gender, SES, age, race, program, traditional EF, academic achievement,

TABLE 2 | Correlation analyses of primary variables.

	CSOT ^a	BD ^a	HTKS ^a	DCCS ^a	PSRA-I ^a	PSRA-A ^a	SC ^a	Agg ^a	AA ^a
CSOT ^a	1								
BD ^a	0.30***	1							
HTKS ^a	0.38***	0.44***	1						
DCCS ^a	0.24***	0.17**	0.36***	1					
PSRA-I ^a	0.15**	0.10*	0.14**	0.15**	1				
PSRA-A ^a	0.22***	0.14**	0.27***	0.24***	0.64***	1			
SC ^a	0.14*	0.12*	0.20***	0.13*	0.14**	0.15**	1		
Agg ^a	-0.07	-0.09	-0.12*	-0.02	-0.17***	-0.08	-0.40***	1	
AA ^a	0.23***	0.32***	0.38***	0.25***	0.17***	0.24***	0.18***	-0.09	1
SC ^b	0.14*	0.09	0.14**	0.16**	0.12+	0.20***	0.57***	-0.29***	0.14+*
Agg ^b	-0.13*	-0.04	-0.04	-0.03	-0.12*	-0.05	-0.28***	0.64***	-0.03
AA ^b	0.20***	0.32***	0.33***	0.18**	0.09	0.20***	0.22***	-0.13**	0.75***
SC ^c	-0.002	0.07	0.11	0.06	0.14*	0.04	0.28***	-0.24***	0.26***
Agg ^c	-0.08	0.04	0.05	0.12	-0.25***	-0.08	-0.10	0.39***	-0.07
AA ^c	0.11	0.19**	0.28***	0.10	0.13*	0.12	0.12	-0.05	0.50***
	SC ²	Agg ²	AA ²	SC ³	Agg ³	AA ³			
SC ^b	1								
Agg ^b	-0.43***	1							
AA ^b	0.19***	-0.09	1						
SC ^c	0.25***	-0.18**	0.28***	1					
Agg ^c	-0.27***	0.49***	-0.15*	-0.43***	1				
AA ^c	0.15*	-0.03	0.53***	0.44***	-0.16*	1			

Abbreviations: AA = academic achievement, Agg = aggression, BD = backward digit span, CSOT = children's size ordering task, HTKS = head-toes-knees-shoulders, PSRA-I = impulse control, PSRA-A = attentional control, SC = social competence.

^aTime 1.

^bTime 2.

^cTime 3.

* $p < 0.05$,

** $p < 0.01$, and

*** $p < 0.001$.

social competence, or aggression [F range = 0.03–3.00, p range = 0.08–0.87]. In contrast, missing cases were significantly different for initial levels of affective indicators of inhibitory control [$F(1,460) = 6.29, p = 0.01, \eta^2 = 0.01$] and cognitive flexibility [$F(1,465) = 4.46, p = 0.04, \eta^2 < 0.01$], whereby missingness was associated with lower scores. Given the small effect size, this effect of missingness was likely minimal.

When examining a correlated traditional and affective EF model, results demonstrated that the model fit the data well [$\chi^2(5) = 9.51, p = 0.09, CFI = 0.99, SRMR = 0.03, RMSEA = 0.04$ (90% CI = 0.00–0.09)]. Additionally, factor loadings were found to be adequate (Howard 2016) for traditional components of working memory ($\beta = 0.61, p < 0.001$), inhibitory control ($\beta = 0.78, p < 0.001$), and cognitive flexibility ($\beta = 0.48, p < 0.001$), as well as affective components of inhibitory control ($\beta = 0.72, p < 0.001$), and cognitive flexibility ($\beta = 0.89, p < 0.001$). Lastly, the affective and traditional EF latent factors were found to be significantly covary ($\beta = 0.38, p < 0.001$). Further discussion of

the confirmatory factor analyses may be found in the [Supporting Information](#).

5.2 | Differential Longitudinal Outcomes of Traditional and Affective Executive Functioning

When assessing the effect of EF across pre-kindergarten (Figure 1), the model fit the data well [$\chi^2(29) = 45.45, p = 0.03, CFI = 0.99, SRMR = 0.03, RMSEA = 0.04$ (90% CI = 0.01–0.05)]. The only significant path was the positive relation between affective EF skills and social competence ($\beta = 0.11, p = 0.04$). Relations were non-significant for traditional EF's effect on academic achievement ($\beta = 0.08, p = 0.14$), social competence ($\beta = 0.01, p = 0.83$), and aggression ($\beta = 0.03, p = 0.53$). Affective EF skills were unrelated to aggression ($\beta = -0.03, p = 0.48$) and academic achievement ($\beta = -0.02, p = 0.71$). The proportion of explained variance was significant for aggression ($R^2 = 0.40, p <$

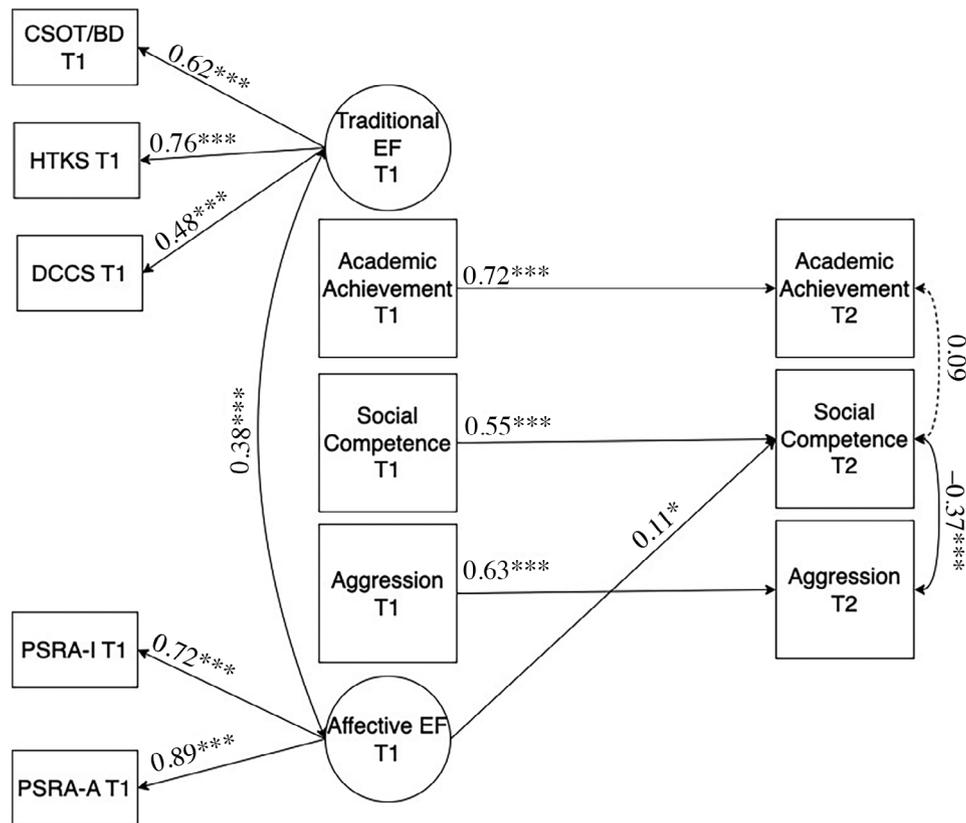


FIGURE 1 | Longitudinal effects of EF on outcomes across pre-kindergarten. *Note:* Longitudinal model illustrating the effect of traditional and affective EF skills at the beginning of preschool on Time 2 (end of preschool) outcomes. Solid paths depict significant effects. Dotted paths reflect non-significant trending ($p < 0.10$) effects. Not depicted are covariance relations among independent variables and non-significant main effects. * $p < 0.05$ and *** $p < 0.001$. BD indicates backward digit span, CSOT = children's size ordering task, DCCS = dimensional change card sort, EF = executive functioning; HTKS = head-toes-knees-shoulders, PSRA-A = attentional control, PSRA-I = impulse control, T1 = Time 1, T2 = Time 2.

0.001), social competence ($R^2 = 0.34, p < 0.001$), and academic achievement ($R^2 = 0.57, p < 0.001$).

When evaluating effects in kindergarten (Figure 2), the model fit the data well [$\chi^2(29) = 58.32, p = 0.001, CFI = 0.96, SRMR = 0.05, RMSEA = 0.05$ (90% CI = 0.03–0.06)]. Traditional EF skills predicted increased academic achievement ($\beta = 0.19, p = 0.04$), whereas affective EF skills were negatively related to aggression ($\beta = -0.17, p = 0.02$). Though non-significant, results also revealed a trending positive relation between traditional EF and social competence ($\beta = 0.15, p = 0.07$) and aggression ($\beta = 0.14, p = 0.09$). Affective EF skills were unrelated to social competence ($\beta = -0.01, p = 0.88$) and academic achievement ($\beta = -0.01, p = 0.91$). The proportion of explained variance was highest for academic achievement ($R^2 = 0.24, p < 0.001$), followed by aggression ($R^2 = 0.16, p < 0.001$), and social competence ($R^2 = 0.11, p < 0.001$).

6 | Discussion

6.1 | Longitudinal Effects of EF

The current study examined the effect of traditional and affective EF skills in two longitudinal models: (1) across the pre-kindergarten year and (2) from the beginning of pre-kindergarten to the beginning of the kindergarten. Unfortunately, due to

methodological limitations, robust parallel indicators using the same informant/method for both cool and hot EF were not available in the current study. However, there were rigorous components that are consistent with traditional measures of EF and those that include affective components, which is what was modeled in the present study. In both models it was hypothesized that a traditional conceptualization of EF, in which EF skills were used in non-affective situations, would uniquely predict academic achievement; and an affective conceptualization of EF would predict social competence and aggression. However, it is plausible that these two latent variables represent EF as measured by behavioral assessment and observer report given the difference in measurement.

Hypotheses were partially supported across both models. First, the affective EF factor was related to increased social competence at the end of pre-kindergarten. These results align with the notion that affective components of EF is important for social development due to the emotion-laden nature of social interactions (Di Norcia et al. 2015; Willoughby et al. 2011). Hot EF is especially crucial in early childhood as children experience an increase in peer interactions (Denham et al. 2009) and learn to achieve social goals while maintaining positive peer relationships (Sebanic et al. 2003). These findings are notable from a sociocultural perspective given that the majority of participants were from a low socioeconomic status. Considering the positive link between

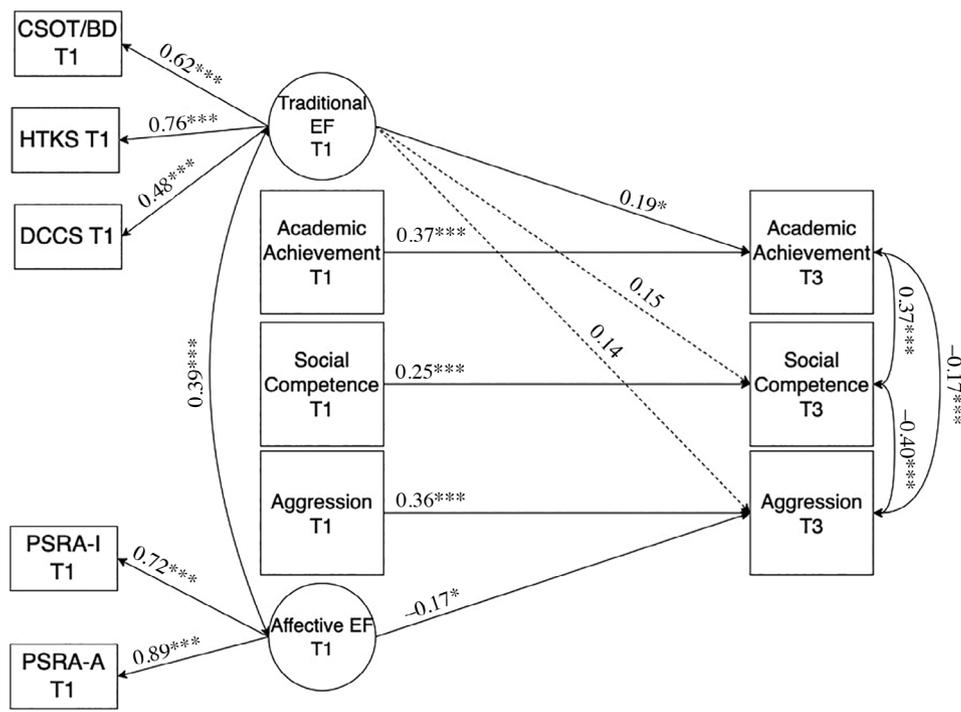


FIGURE 2 | Longitudinal effects of EF on outcomes in kindergarten. Longitudinal model illustrating the effect of traditional and affective EF skills at the beginning of preschool on kindergarten outcomes. Solid paths depict significant effects. Dotted paths reflect non-significant trending ($p < 0.10$) effects. Not depicted are covariance relations among independent variables and non-significant main effects. * $p < 0.05$ and *** $p < 0.001$. BD = backward digit span, CSOT = children’s size ordering task, DCCS = dimensional change card sort, EF = executive functioning HTKS = head-toes-knees-shoulders, PSRA-A = attentional control, PSRA-I = impulse control, T1 = Time 1, T3 = Time 3.

socioeconomic status and social skills (Parker et al. 2023), these findings suggest that well-developed affective features of EF skills may act as a protective factor.

Contrary to hypotheses, affective EF skills were unrelated to social competence when predicting effects into kindergarten. Perhaps this lack of replication reflects how preschool and kindergarten teachers differ in their attention toward social skills. Although social skills are important to teachers at both grade levels, pre-kindergarten teachers may be able to better attend to prosocial behaviors given the increased academic demands in kindergarten (Abry et al. 2015). Thus, it may be that children rely more heavily on affective EF skills in pre-kindergarten to meet teacher’s expectations.

Beyond promoting adaptive social development, the current results also demonstrate that affective EF skills are uniquely associated with decreases in aggression across the transition to kindergarten. Though not distinguished in the current study, these results align with a reactive conceptualization of aggression (i.e., aggression that is impulsive and/or motivated by anger due to a perceived offense or threat; Card and Little 2006). Given that strong emotions are embedded in this definition of aggression, affective EF skills are likely necessary to regulate these aggressive outbursts. Hot inhibitory control may be especially important as it allows a child to inhibit impulsive dominant responses, such as physical aggression (Backer-Grøndahl, Nærde, and Idsoe 2018; Kim et al. 2013). Inhibition of aggressive reactions may be particularly important in kindergarten as aggression is regarded as more inappropriate as children transition to formal schooling

(Archer and Coyne 2005). This in turn may explain why affective EF skills were related to aggression in kindergarten, but not across pre-kindergarten. The function of aggression may also explain the trending positive relation between traditional EF skills and aggression. Unlike reactive aggression, proactive aggression is goal-directed and functions instrumentally to achieve a desired resource (e.g., social status, toys; Card and Little 2006). Proactive aggression is conceptualized to be more “cold-blooded” and require planning—a higher order function of EF (Card and Little 2006). The premeditated nature of proactive aggression may mean this is more closely related to cool EF (Poland, Monks, and Tsermentseli 2016). This study may operationalize aggression to encompass both proactive and reactive aspects and that traditional and affective EF skills are accounting for variance from proactive and reactive aggression, respectively. That said, this interpretation is tentative given the non-significant link between traditional EF and aggression and because the current operationalization of aggression does not distinguish the function of aggression.

The final hypothesized relation that was supported by current analyses is the positive link between traditional EF and academic achievement in kindergarten. Cool EF is thought to facilitate learning-related behaviors such as attending to class information, shifting attention to relevant details, and problem-solving (Brock et al. 2009; Denham et al. 2012; Nesbitt, Farran, and Fuhs 2015). Spiegel et al. (2021) suggest that young children rely heavily on cool EF skills in their early schooling as tasks are more effortful and less automatized. Cool working memory has been found to be especially important in academic success, relative

to inhibitory control and cognitive flexibility (O'Toole et al. 2020). According to prior work, working memory facilitates learning-related behaviors and is consequently essential for many academic tasks (e.g., literacy, numeracy; O'Toole et al. 2020). That said, traditional EF skills were found to be unrelated to academic achievement in pre-kindergarten. One explanation for this may be the different emphasis that is placed on academic competence in preschool versus kindergarten (Abry et al. 2015). Although building upon academic skills is a core component of preschool and kindergarten, kindergarten typically allocates more time to this area of growth (Abry et al. 2015). It is also possible the discrepant results were due to the differences in operationalization of academic achievement in pre-kindergarten and kindergarten.

6.2 | Limitations and Future Directions

When interpreting the current results, it is important to acknowledge the limitations of the current project. Given the secondary nature of these analyses, this study was limited in its methodology. Whereas traditional components of EF were measured using behavioral tasks, affective components of EF were operationalized using research assistant report on the PSRA-AR. Thus, the two-factor model may reflect differences in measurement. Under this interpretation, higher performance on behavioral EF assessments is associated with increased academic achievement, whereas observer-report ratings are closely linked to social behaviors. It will be important for future work to operationalize these components of EF using both observer-report and behavioral assessments to ensure that differences in factor structure are not merely due to shared method. Beyond informant, there were also limitations regarding some of the variable operationalizations. For instance, the HTKS was developed to measure all three traditional components of EF and thus is not a pure measure of inhibitory control. Similarly, the PSRA-AR may capture self-regulatory skills beyond EF, such as emotion regulation (Geiger 2019; Smith-Donald et al. 2007).

Along with the operationalization of EF, there were also conceptual issues with the SSIS, which was used to measure social competence, aggression, and kindergarten academic competence. There were items in both the aggression (e.g., “Does things to make others feel scared”) and social competence (e.g., “Says please”) scales that did not align with typical conceptualizations of these constructs (Crick, Casas, and Mosher 1997; McKown et al. 2009). Similarly, the academic competence scale included items that measured academic motivation and general intelligence, which, although related to academic achievement, are not its core characteristics (Lassiter and Bardos 1995; Zee, Rudasill, and Bosman 2021). The secondary nature of analyses also prevented calculation of reliability statistics across variables using the specific sample. Ultimately, it will be important for future work to conduct analyses using valid and reliable measures of their specified construct.

6.3 | Applied Implications

This project provides insight into understanding the role of EF on social and academic outcomes across the transition to kinder-

garten. Whereas prior early childhood work has often examined EF's effects within the same school year (e.g., Brock et al. 2009), results from this study demonstrate effects with EF and various outcomes across grades. Results from the current study also have the potential to inform intervention efforts. Future EF interventions should use measures that account for traditional and affective EF skills to assess children's progress comprehensively. Zelazo and Carlson (2022) emphasize that teaching metacognitive skills, such as reflection, in conjunction with EF interventions will be crucial for the generalization of skills. Advancements in EF intervention studies are particularly relevant given the sample of the current study. Children from low socioeconomic status backgrounds often display lower levels of academic and socio-emotional skills at the beginning of kindergarten (Kuhfeld, Condrón, and Downey 2021). This study may inform preventative approaches, such as developing pre-kindergarten educational curriculums that target growth in EF. Not only may such an approach foster increased school readiness in kindergarten, but it may also promote lasting effects on children's cognitive and socio-emotional skills across development.

Data Availability Statement

The data that support the findings of this study are openly available in Inter-university Consortium for Political and Social Research at <https://doi.org/10.3886/ICPSR37521.v1>.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.