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ORIGINAL PAPER

Linking Attachment and Executive Function Systems: Exploring Associations in a Sample of Children of Young Mothers

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Abstract

Attachment and executive function (EF) are two related systems that develop early in life and may mediate associations between care experiences and later functioning. Though theoretically related, the associations between attachment and EF have not been fully explored among children experiencing adversity. In the current study, we took a person-centered approach to examining attachment representations and EF among children of adolescent mothers. Using Latent Profile Analysis, we identified three groups of attachment representations: a "secure" group, an "insecure-avoidant" group, and an "insecure-disorganized" group. We then explored differences in EF performance across the identified groups. Our results indicated that the "secure" group generally outperformed the "insecure-disorganized" and "insecure-avoidant" groups. Though the "insecure-avoidant" group generally outperformed the "insecure-disorganized" group, significant differences were found only on one task. Our findings document links between attachment and EF among children experiencing adversity and may suggest that prevention or intervention efforts to support the development of secure attachments will also foster optimal EF, those higher-order cognitive processes that drive goal-directed behavior.

Keywords Attachment representations · Executive function · Adolescent mothers · Narrative story stem tasks · Socio-emotional development

Highlights

- Secure attachment representations are related with more optimal executive function.
- There are similarities between secure and insecure-avoidant children's executive function.
- There are minimal differences among insecure subtypes in executive function performance.

The quality of early parent–child interactions influences children's development across a variety of domains (e.g., Sroufe 2000, 2005). For instance, infants depend upon caregivers' assistance for physical and emotional regulation (Bernier et al. 2010). Accordingly, the consistency and quality of caregivers' responses to their infants' needs are internalized by children and may potentially influence later development (Sroufe 2000, 2005). This internalization of early caregiving activities can be seen in the expression of children's attachment representations (Bretherton 1990). The attachment system modulates autonomic and behavioral arousal in response to fear-producing stimuli through the maintenance of proximity to caregivers who provide safety and a secure base for exploration (Cassidy 2008). Both directly, and through cognitive representations of attachment (i.e., attachment representations), early care experiences may influence later developmental functioning (Bretherton 1990). From seminal attachment studies of young children (e.g., Ainsworth et al. 1978; Main and Solomon 1990) four predominant patterns of attachment behaviors have been identified (secure, insecure-avoidant, insecure ambivalent/resistant, disorganized). As children develop increasing cognitive capacities, attachment patterns can be assessed not only by behavioral interactions, but also by measures that index cognitive representations of nurturant care, protection, acceptance/rejection, and

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disorganization elicited from emotionally distressing or relationally charged situations (Holmberg et al. 2007). Research has shown that these four patterns of attachment behaviors and representations are associated with several aspects of socioemotional and cognitive functioning in early childhood (e.g., Drake et al. 2014).

Theoretically and empirically linked to attachment through shared influences of early parenting experiences such as parental sensitivity (for a review, see Fay-Stammbach et al. 2014), Executive Function (EF) is an early childhood system that refers to higher-order cognitive processes driving goal-directed behaviors (Hofmann et al. 2012). EF is implicated in a variety of domains, such as peer acceptance and academic motivation (Blair 2002). Studies demonstrate that EF partly emerges in response to early parent–child relationships (Fay-Stammbach et al. 2014), though other mechanisms (e.g., neurobiological, genetic) also play a role. Both theory and research suggest links between attachment and EF (Bernier et al. 2010; Fay-Stammbach et al. 2014). Although both attachment and EF develop and consolidate across early childhood, relations between attachment representations in early childhood (as opposed to attachment behavior in infancy) and children's EF performance have not been thoroughly explored, especially among samples of children experiencing adversity, such as poverty or parenting challenges. For instance, children born to adolescent mothers are at risk for compromised socio-emotional and cognitive developmental functioning and are more likely to live in settings marked by numerous contextual stressors (Mollborn and Dennis 2012; Rafferty et al. 2011), thus they may be more likely to have challenges to developing both secure attachment representations and EF. Accordingly, in the current study, we explored associations between attachment representations and EF in a sample of school-aged children born to adolescent mothers. Specifically, we aimed to (1) document whether we could replicate the four attachment classifications found in the literature using Latent Profile Analysis of children's attachment representations assessed from a narrative story completion task; and (2) explore associations between the identified attachment classifications and children's EF.

Lifespan Influence of the Attachment System

An important goal of the child–parent attachment system is the modulation of behavioral arousal under threat or fearful situations. According to an attachment theoretical perspective (Bowlby 1973) the protection provided by the adult attachment figure for their dependent young allows for children's continued positive developmental trajectories; in the cognitive domain this includes movement toward the more sophisticated cognitive processes involved in EF. Infants depend on caregivers' assistance in physiological, emotional, and behavioral regulation, gradually developing cognitive, motor, and social skills to move towards self-regulation (Bowlby 1958). Based on caregivers' interaction patterns, infants begin to develop cognitive representations of their expectations of self, others, and the world referred to as "Internal Working Models" (IWM; Cassidy 2008). Established patterns of attachment behavior (e.g., secure, insecure-avoidant, insecure-ambivalent/resistant, insecure-disorganized; Ainsworth et al. 1978; Main and Solomon 1990) reflect these IWM expectations and are associated with variations in sensitive and responsive caregiving, mental representations, and adverse living environments (e.g., history of trauma, toxic stress; Benoit 2004; Cassidy and Berlin 1994).

With development into early childhood, representational thinking (i.e., IWM) becomes increasingly accessible, and the quality of attachment representations can be evaluated with projective measures such as story completion task representations of attachment, which require children to draw upon IWMs of their own attachment figures in completing stories depicting parents and children in emotionally distressing situations (Bretherton and Oppenheim 2003; Holmberg et al. 2007). One of the most well-known of these story completion tasks is the MacArthur Story Stem Battery (MSSB), which probes children's IWMs by asking children to complete stories portraying caregivers and children in emotionally distressing situations (Bretherton and Oppenheim 2003; Holmberg et al. 2007). Children's responses can be assessed in several different ways, such as by examining representations of prosocial behaviors, empathy, as well as attachment representations (Holmberg et al. 2007).

A large body of work has shown associations between children's secure attachment behaviors/representations and functioning beyond the attachment relationship (Drake et al. 2014), for example, in social competence (e.g., Rispoli et al. 2013), achievement and mastery motivation (e.g., Moss and St-Laurent 2001), and behavior regulation (e.g., Woodhouse et al. 2009). Further, insecure attachment in infancy is related to poorer socio-emotional development during the preschool years (Kochanska et al. 2009).

Ecological models (Bronfenbrenner and Morris 2007) suggest that the complex environments in which the parent–child relationship is situated influence developing behavioral systems. Stressors like poverty can induce parental strain, leading to fewer physical and emotional resources available to optimally respond to children's need for self-regulation assistance (Kohen et al. 2008). As a result, children may develop coping mechanisms that are maladaptive in broader contexts, which may manifest as insecure attachments and difficulties in appropriate self-regulation (Blair 2010; Mikulincer et al. 2003). For example, avoidant attachment behaviors that function to minimize the distress of having a rejecting or non-responsive parent may also manifest as avoidant coping strategies when emotional arousal becomes overwhelming in contexts beyond the parent–child relationship. Research demonstrates that adolescents with high attachment avoidance show elevated physiological arousal in conflict situations with peers (e.g., Gallo and Matthews 2006). Other studies have found that adolescents with avoidant attachment styles have fewer and less intense intimate relationships (Feeney et al. 1993) as well as experience lower relationship satisfaction than their secure peers (Collins et al. 2002). Thus, individuals may adopt avoidant behaviors as a means of regulating potential distress in attachment-related contexts (Mikulincer et al. 2003).

Influences on Emerging Executive Function (EF)

Similar to children's attachment representations, EF begins to develop in early childhood (Diamond 2014). EF consists of distinct but interrelated higher-order cognitive processes and includes three components: working memory, cognitive flexibility, and inhibitory control (Diamond 2014). Though these facets of EF are fully differentiated in adulthood, each facet exists in an interrelated nascent capacity in childhood (e.g., Wiebe et al. 2011). EF, as a construct, straddles both cognitive and socio-emotional domains, thus, EF may underlie self-regulatory behaviors which involve the synchronization of emotional arousal as well as cognitive control (Blair and Diamond 2008). Fostering EF in early childhood is critical, as the period of birth to three is a time of rapid development and differentiation of the neuronal pathways related to EF (Shonkoff et al. 2012). Given the importance of this time period in the proliferation of the EF-related pathways, experiences early in life, such as parent–child interactions, can impact later EF (Grant et al. 2003). Parental sensitivity, associated with children's attachment patterns, also has been linked with variations in EF (Bernier et al. 2012). By responding to young children in a sensitive manner, parents manage children's stress responses, promoting both secure attachment and later EF by both providing children with a framework for successful self-regulation, and mitigating stress that may impair EF processes (Gunnar and Quevedo 2007).

Associations between Attachment and EF Processes

De Ruiter and van IJzendoorn (1993) theorized that attachment and cognition are related to one another through various processes, including enhancing exploration, learning from the attachment figure, and children's metacognitive capacities. More specifically, they hypothesized that secure attachment representations lead to more coherent IWMs, thus promoting cognitive development. Conversely, insecure IWMs are comprised of multiple competing representations of attachment behavior; thus, negotiating the stress evoked by these conflicting representations may hinder developing cognitive processes. Although we are not examining a causal framework, our study is informative in investigating whether attachment representations in early childhood are concurrently associated with executive function. Further, De Ruiter and van IJzendoorn (1993) suggested that research exploring associations between attachment and cognition needs to uniquely consider the high-risk contexts as separate from low-risk contexts, due to factors present in high-risk settings that could adversely influence both attachment and cognitive development (e.g., parental psychopathology, lower financial resources). Our study adds to the literature in this way by examining these questions within a high-risk sample.

Despite the theoretical links between attachment and EF in adverse contexts, current studies are equivocal in their findings or primarily explore associations between EF and attachment in relatively low-risk samples. In general, research considering the relationship between children's attachment status and the more cognitive components comprising EF have depicted higher analytical, language, and academic performance among children displaying secure attachment behaviors (e.g., Spieker et al. 2003) and less optimal performance among children with disorganized attachments (e.g., O'Connor and McCartney 2007). Further, Bernier et al. (2015) showed attachment security related to optimal EF skills among children entering school. Moreover, Bohlin et al. (2012) found that disorganized attachment was linked with low EF performance in early childhood.

However, the research examining cognitive performance in children with insecure-avoidant or ambivalent attachments specifically has yielded mixed results. For instance, studies tend to find small numbers of children classified as insecure-avoidant and insecure-ambivalent and may even combine them into a single group (e.g., Stievenart et al. 2011). Jacobsen et al. (1994) found that children with insecure-avoidant attachments scored lower than children with secure attachments on a battery of cognitive assessments and that there were only modest differences between the avoidant and disorganized groups tested at age seven. In another study, Granot and Mayseless (2001) reported that children with insecure-avoidant or insecure-disorganized attachment classifications did not significantly differ from one another on measures of school functioning (academic achievement, peer acceptance, behavior problems).

However, in a meta-analysis examining attachment status with effortful control—analogous to the EF component of inhibitory control—Pallini et al. (2018) determined that children with secure attachments displayed higher effortful control than children with insecure attachments, and that children with organized attachments (e.g., secure and insecure) showed higher effortful control than those with disorganized attachments. Therefore, despite the fact that some research depicts attachment organization as related to greater EF performance than attachment disorganization, further work must be conducted to make sense of the conflicting findings regarding cognitive functioning among children with insecure and disorganized classifications.

There have been only a few studies examining attachment classifications and EF performance that have included children from high-risk samples. For instance, in a low-income high-risk sample, high overall attachment security to caregivers was associated with higher EF performance in middle childhood (Meuwissen and Englund 2016). An investigation of an intervention aiming to strengthen attachment relations between foster parents and toddlers (Lind et al. 2017) found that intervention dyads displayed higher EF performance, compared to the control group, and their EF skills rivaled those of the low-risk group. In sum, as the research depicts that the various dimensions comprising attachment classifications (i.e., security, avoidance, organization) are associated with differences in cognitive performance, presumably these different features of attachment representations may manifest in individual variation on different EF skills; however, further work must be done to explore these associations as well as consider these unique differences among children experiencing adverse circumstances.

The Present Study

As stress in the early caregiving context influences both attachment and EF, the present study investigated these issues in a sample of children of adolescent mothers, a group likely to experience considerable stress and adverse circumstances. Children of adolescent parents constitute an at-risk group, for adolescent parenthood is often associated with considerable stressors and fewer resources to mitigate the potential impacts of these stressors (Mollborn and Dennis 2012). In addition, children of adolescent mothers are at greater risk for poorer self-regulatory skills, related to EF processes (Rafferty et al. 2011). Further, though attachment and EF are theoretically associated, the work exploring the associations between different manifestations of early attachment representations on EF remains equivocal, especially among children experiencing adverse circumstances. Accordingly, in the present study, we investigated relations between patterns of attachment representations and EF skills among children of adolescent mothers.

Specifically, our first aim was to identify whether the attachment patterns classified by Ainsworth et al. (1978) and Main and Solomon (1990), could be replicated by conducting Latent Profile Analysis (LPA) on children's attachment representations derived through a coding scheme solely focused on attachment behaviors (the Attachment-Focused Coding Scheme [AFCS]; Reiner and Splaun 2008) among a subset of four MSSB stories. We hypothesized four subgroups of children based on the representations—a "secure" group, an "insecure-avoidant" group, an "insecure-ambivalent" group, and an "insecure-disorganized" group. Our second aim was to determine whether the identified subgroups differed on EF, though we were not aiming to examine whether attachment played a causal role in EF. Informed by the literature linking secure attachment behaviors with more optimal cognition, we hypothesized that children in the "secure" group would display the highest performance on EF tasks compared to all other groups. As research has consistently depicted negative associations between disorganized attachment behaviors and cognition (Claussen et al. 2002; Jacobsen et al. 1994; Moss and St-Laurent 2001) we hypothesized that children classified in the "disorganized" group would display the lowest EF performance.

Method

Participants and Procedure

Our study sample consisted of 331 children of adolescent mothers. The current study is embedded in a longitudinal evaluation study of a voluntary home visiting program for first-time young parents under the age of 21 (Tufts Interdisciplinary Evaluation Research [TIER] 2017). The home visiting program aimed to support maternal and child well-being through a variety of means, such as the promotion of positive parenting and the prevention of child maltreatment. Initially, 704 mothers were recruited for the study and were either assigned to a program group that received home visiting services or a control group that did not receive home visits but instead were provided with referrals to other support services (TIER 2017). The main goal of the present study was not related to the intervention program, therefore, program assignment was not used to differentiate participants in the current study.

The current analyses used data from Time 5 (T5) (when children were about six years of age) and included participants with usable data who agreed to in-home data collection visits and consented to the filmed narrative task. In preliminary data analyses, we verified that our analytic

Table 1 Sample demographic information

Maternal characteristics	
Age at Birth (in years)	$M = 18.8$, $SD = 1.30$
Race/ethnicity	
Non-Hispanic White	32.7%
African American	21.8%
Hispanic	38.2%
Other	7.30%
Relationship status	
Single	52.6%
In a committed relationship/ married	47.4%
Living arrangements	
Lives alone or with roommates	40.5%
Lives with parental figures	23.2%
Lives with partner	36.3%
Median Household Income from U.S. 2010 Census	
Less than $15,000	7.60%
$15,000–$30,000	17.2%
$30,000–$45,000	22.3%
$45,000–$60,000	26.6%
$60,000–$75,000	12.4%
More than $75,000	13.9%
Child characteristics	
Age (in years)	$M = 6.19$, $SD = 0.54$
Sex	
Male	53.2%
Female	46.8%

sample did not significantly differ from the larger study sample on key demographic features. Table 1 contains demographic information about the study sample. The sample was relatively diverse in race/ethnicity (32.7% Non-Hispanic White, 21.8% African American, 38.2% Latino/Hispanic, and 7.3% identifying as another racial category). Children in the final study sample were approximately 6 years of age ($M = 6.19$, SD = 0.54) and 53.2% were male.

Measures

Attachment representations

Attachment representations were assessed using the MacArthur Story Stem Battery (MSSB; Bretherton and Oppenheim 2003), an interactive story completion task that aims to capture preschool and school-age children's socio-emotional representations (Holmberg et al. 2007). Children were asked to complete story prompts, provided by the examiner, through narration and/or the physical manipulation of toys (Holmberg et al. 2007). The scoring of the task does not require verbal production; both verbal and non-verbal children can be scored similarly based on the story they portray with the toys. The MSSB was designed to tap into different aspects of children's cognitive representations such as children's expectations of adults' responses in dilemmas or children's abilities to cope with negative emotions (Bretherton and Oppenheim 2003).

In order to assess children's attachment representations, responses to the MSSB were coded using the Attachment-Focused Coding Scheme (AFCS; Reiner and Splaun 2008). The AFCS was used to assess four stories from the full MSSB that are designed to activate children's attachment system (Reiner and Splaun 2008). Each story introduces a dilemma that prompts the child to seek an attachment figure for assistance; two broad coding dimensions are assessed: maternal focused subscales (i.e., supportive mother, rejecting mother, attachment avoidance) and child-focused subscales (i.e., dysregulation, theme and negative emotion avoidance, theme and negative emotion resolution; Reiner and Splaun 2008). The maternal focused codes examine whether children represent their mothers as supportive ("supportive mother") or rejecting ("rejecting mother") as well as whether they avoid their mothers as attachment figures in stressful situations ("attachment avoidance"; Reiner and Splaun 2008). The child-focused codes examine the level of disorganization and behavioral dysregulation present in the story response ("dysregulation"), whether children avoid the negative story content and negative emotions ("theme and emotion avoidance"), and whether children are able to resolve the primary dilemma present within each story ("resolution"; Reiner and Splaun 2008).

Each of the four stories is coded on these six subscales. Each subscale is scored on a one to five scale; higher scores on the "supportive mother" and "resolution" subscales indicate more optimal attachment representations, while lower scores on the "rejecting mother", "attachment avoidance", "theme and emotion avoidance", and "dysregulation" subscales indicate more optimal attachment representations (Reiner and Splaun 2008). Although the AFCS subscales tap into several domains of attachment representations, the coding scheme does not yield specific attachment classifications for children, which was our rationale for conducting Latent Profile Analysis to determine if we could find profiles of attachment representations that matched extant attachment classifications. In our study, we created total scores on each subscale for participants by summing the scores on the six subscales across each of the four stories.

Cases were scored by a team of four trained coders and 25% of cases were coded by two coders; ICCs were calculated by an absolute-agreement two-way mixed-effects model. ICCs for each code ranged from 0.86 to 0.92, averaging 0.88. The AFCS has been used in samples experiencing high adversity as well as in both clinical and nonclinical populations. The coding scheme has been validated for use among four to eight-year-old children as well as within samples with a diverse range of racial/ethnic backgrounds (Splaun et al. 2010). The AFCS codes have been shown to be discrete from one another, yet still theoretically related to one another (e.g., children who score higher on "supportive mother" were less likely to also score high on the "rejecting mother" subscale; Splaun et al. 2010). In addition, the AFCS has been validated against two previously established coding schemes of the MSSB (MacArthur Narrative Coding Manual and the Little Piggy Coding Scheme; Reiner and Splaun 2008). Moderate to strong significant correlations between the established coding schemes and corresponding AFCS codes were found in the expected directions (Reiner and Splaun 2008; Splaun et al. 2010).

Executive Function

Four measures of executive function (EF) were assessed during the T5 research interview; they tapped into the different components of EF (i.e., working memory, cognitive flexibility, and inhibitory control). Though each measure involved one aspect of EF more strongly than the others, due to the developing nature of EF in early childhood each measure also implicated all EF skills holistically (e.g., Wiebe et al. 2011).

Corsi-block tapping task

In order to assess working memory and cognitive flexibility, the Corsi-block tapping task (Orsini 1994) was used. Children are presented with nine plastic cubes and are asked to replicate a tapping sequence in a forward or reverse order. The forward condition assesses children's working memory; the backward condition additionally assesses cognitive flexibility. As children correctly reproduce sequences, the conditions progress in difficulty, by adding an extra tap to the sequence. Both conditions are made up of levels, with two sequences per level. Children must get one out of two sequences correct to progress to the next level. In the current study, a proportion score for each task was calculated to reflect the highest level of blocks children achieved relative to the total number of levels per task. The Corsi task has been used in several diverse samples including primarily European American, bilingual, and international samples (e.g., Carvalho et al. 2014). Convergent validity with the Wechsler Intelligence Scale for Children—Revised (WISC-R) has also been established (Orsini 1994).

Digit-span task

The Digit Span (DS) task (Levine 1984) most directly involves working memory and cognitive flexibility and consists of the digits forward (DF) and digits backward (DB) conditions. The forward condition assesses working memory and the backward condition also assesses cognitive flexibility. Examiners read a sequence of digits and children are asked to repeat the sequence or recall the sequence in reverse order. The conditions are comprised of different levels (eight in DF and four in DB), contain six lists per level, and include varying digits, beginning with two digits. If children correctly repeat four out of six lists in a level, they advance to the next level with an additional digit. Children receive one point for each list completed; a total score for each participant is computed. The DS task is analogous to the digit span of the Wechsler Intelligence Scale for Children (WISC-III; Wechsler 1991), which demonstrates acceptable reliability ($\alpha = 0.78$) in middle childhood (Beebe et al. 2000; Levine 1984) and adequate test-retest reliability in the forward ($ICC = 0.69$) and the backward tasks ($ICC = 0.60$) (Beebe et al. 2000; Levine 1984). This task has been used extensively to assess working memory and cognitive flexibility among samples of racially and ethnically diverse children (e.g., Ostrosky-Solís and Oberg 2006).

Dimensional card change sort task (DCCS)

The DCCS task was designed to tap into children's cognitive flexibility (Zelazo 2006). Examiners show children cards that can be sorted on the dimensions of shape and color. There are three phases. In the first phase (pre-switch), children are asked to sort six cards based on color. In the second phase (post-switch), children are asked to sort the same six cards based on shape. If children score five out of six correctly on the post-switch phase, they pass to the third (border) phase. In this phase, children are presented with twelve cards, some including borders, and are asked to sort the cards by color if there is a border, or by shape if there is no border (Zelazo 2006). Children receive one point for each correct response; a total correct sum score on the post-switch phase was used in our study. The DCCS task has been validated in racially and ethnically diverse samples (e.g., Ng et al. 2015). DCCS displays high test-retest reliability (Beck et al. 2011) and significant convergent validity with the Wechsler Preschool and Primary Scale of Intelligence Block Design (Zelazo et al. 2013).

Head toes knees shoulders task (HTKS)

Cognitive flexibility and inhibitory control were measured by the HTKS (Ponitz et al. 2008). In this task, examiners initially ask children to play a game where children touch the part of their body that the examiner names (e.g., "touch your head"; "touch your toes"; "touch your knees"; "touch your shoulders"). A rule is then added that requires children to touch the opposite of what the examiner says (e.g., "touch your head" means "touch your toes"). The task consists of two phases. The first phase is the Head-to-Toes-Task (HTT) where "head" is paired with "toes," yielding ten instructions. Children only move to the next phase when they achieve four correct pairings. In the second phase, examiners introduce "shoulders" to be paired with "knees," along with the original "head" to "toes" pairing. This phase consists of twenty instructions. Each correct response yields two points; a self-corrected response yields one point. Twenty points are possible in the first phase and forty points in the second phase (overall possible score of sixty points). A sum score is calculated by adding together the number of points a child receives in each block. If children do not pass to the second block, they do not receive any points for that block (HTKS; Ponitz et al. 2008). HTKS is widely used in both racially and ethnically homogenous as well as heterogeneous samples (e.g., Wanless et al. 2011) and has been found to have strong inter-rater reliability. The HTKS displays convergent validity with teacher ratings of behavioral regulation tasks (Ponitz et al. 2008).

Demographic Features of Profiles

To examine features of profile membership, we explored demographic variables across profiles after profile estimation to prevent profile misspecification, following the recommendations of Nylund-Gibson and Masyn (2016). Variables included were among the standard set of controls as well as those that may potential influence EF performance as well as profile membership: child age, sex, language, and mother-reported ethnicity. To account for differential patterns of missing data, we conducted a series of bivariate analyses and logistic regression analyses to classify patterns of missing data with observable sample characteristics. Results of the missing data analyses indicated significant associations between missing status and child ethnicity, child age, involvement with child protective services. These variables were therefore included as auxiliary variables in the profile enumeration stage of analysis.

Results

Analytic Approach

Analyses were performed in two stages. First, the subgroups of children's attachment representations were identified using LPA with the six continuous indicators of attachment subscales from the AFCS. Following, in order to determine whether attachment representations were associated with EF, we examined relations among profile membership and children's performance on EF tasks using the automatic Bolck–Croon–Hagenaars (BCH) method (Asparouhov and Muthén 2014). The BCH method is used to explore differences on a continuous variable among latent categorical variables (i.e., profile membership) in order to account for the probabilistic nature of the latent categorical variables (Asparouhov and Muthén 2014). Preliminary analyses were conducted in R version 3.2.3 (R Core Team 2015) and subsequent analyses were conducted with Mplus software (version 8.0) using full information maximum likelihood (FIML) to account for missing data (Muthén and Muthén 1998–2016).

LPA is a model-based classification technique to identify latent groups of individuals with similar response patterns on continuous indicators. Model estimation occurs in a sequential fashion, where a one-profile model is first tested and profiles are systematically added until a final profile solution is identified based on acceptable model fit indices: the Bayesian information criterion (BIC; Schwarz 1978), the Lo-Mendell-Rubin Adjusted Likelihood Ratio Test (LMRT; Lo et al. 2001), and the Bootstrapped Likelihood-Ratio Test (BLRT; Arminger et al. 1999; Masyn 2013) as well as substantive interpretability. Models that minimize the BIC and tend to have significant LMRT and BLRT values are preferred (Raykov 2016). Model entropy and average posterior probabilities are also considered in selecting the most parsimonious profile. Entropy values closer to one suggest minimal model misclassification (Raykov 2016). Posterior probability values provide information about the amount to which cases were assigned to the appropriate profile, thus values closer to one for each model suggested profile; values closer to zero for all other profiles indicate high profile separation (Raykov 2016).

As discussed earlier, the BCH method explores associations between latent categorical variables (i.e., profile membership) and observed continuous variables (i.e., the covariates of interest). Observed variables are not included in the original profile specification due to the misclassification that can occur with the inclusion of these items. The automatic BCH method prevents class shifting at all stages of analyses and provides estimates of the mean value of covariates across the profiles while accounting for measurement error. The BCH approach can be thought of as analogous to the ANOVA method of mean comparison, yet the BCH approach accounts for the probabilistic nature of latent profile membership in viewing mean differences among variables of interest. An overall X^2 test and pairwise tests are provided to assess differences in the mean values of covariates across profiles (Asparouhov and Muthén 2014).

Profiles of Attachment Representations

Our first study aim was to identify whether we would replicate the four attachment classifications within our study sample. Therefore, we first estimated a series of models specifying one to four profiles to establish the different subgroups of attachment representations. Fit indices for each model are provided in Table 2. Based on model fit indices as well as theoretical interpretability, we selected a three-profile model solution. Figure 1 displays the standardized means of the AFCS codes by each Latent Profile. As the AFCS measure was validated against pre-existing, validated, and widely used attachment measures, the attachment dimensions of each profile were interpreted based on Ainsworth et al. (1978) and Main and Solomon's (1990) classifications (Splaun et al. 2010). We identified a "secure-profile" ($n = 84$, 25% of total sample), an "insecure-avoidant profile" ($n = 182$, 55% of total sample), and an "insecure-disorganized profile" ($n = 65$, 20% of total sample). Table 3 provides demographic information on covariates related to each profile. As displayed in Fig. 1, children likely classified to the "secure" profile displayed the highest overall supportive mother representations and the lowest rejecting mother, attachment avoidance, and dysregulation representations. Moreover, children likely in the "secure" profile, on average, resolved the distressing themes elicited in each narrative story stem and did not avoid negative themes and emotions addressed by each story stem. Children likely within the "insecure-avoidant profile" displayed moderate supportive mother representations and high attachment avoidance representations. They also displayed moderately low rejecting mother representations and dysregulation representations. Moreover, children likely in the "insecure-avoidant" group tended not to fully resolve the distressing themes elicited by each story stem and were, on average, higher than the other groups in avoiding the negative themes and emotions elicited by each story stem. That is, children within the "insecure-avoidant" avoided both negative themes and emotions more than children in the "secure" group, who tended to address the negative themes and emotions. Finally, children likely in the "insecure-disorganized" profile, on average, displayed moderate supportive mother representations. They also displayed the highest dysregulation, rejecting mother, and attachment avoidance representations. In addition, compared to the other two groups, the "insecure-disorganized" group both readily acknowledged and fixated on negative themes and emotions in each story stem and were more likely to leave each narrative unresolved.

Table 2 Comparison of diagnostic fit indices for all latent profile models tested

Profile	BIC	LMR *p* value	BLRT *p* value	Entropy
1	8753.660	N/A	N/A	N/A
2	8411.807	0.001	0.001	0.920
3	8349.982	0.040	0.040	0.894
4	8299.609	0.090	0.090	0.820

Associations of Profile Membership with EF Correlates

The second research aim was to examine the relations between profile membership and children's concurrent EF. Therefore, the equality of means of children's performance on the four EF tasks (the forward and backward conditions of the Digit Span and Corsi Block Tasks, the HTKS task, and the DCCS task) was tested across profiles using the BCH method (Asparouhov and Muthén 2014). Differences between profiles on EF are presented in Table 4. To address multiple comparisons, we utilized a conservative approach by applying, to all our analyses, a Bonferroni correction with a family-wise error rate of $\alpha = 0.10$, yielding a corrected $\alpha = 0.02$. We used the nominal alpha value of 0.10 to account for the overly stringent nature of the Bonferroni correction (e.g., Perneger 1998; Lindquist and Mejia 2015). Children in the "secure" profile scored significantly higher (all p's < 0.001) on all tasks compared with children in the "insecure-disorganized" profile. Moreover, children in the "secure" profile scored significantly higher than children in

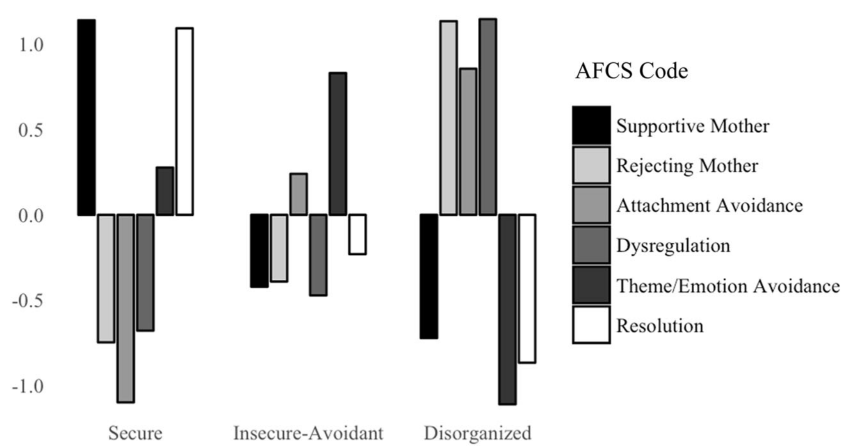

Fig. 1 Standardized means of AFCS codes across attachment representation profiles

Table 3 Demographic differences by attachment representation latent profile

	Secure profile (S)		Insecure-avoidant profile (A)		Insecure-disorganized profile (D)					
	M	*SE*	*M*	*SE*	*M*	*SE*	Overall $X^2(2)$	S vs. A $X^2(2)$	A vs. D $X^2(2)$	D vs. S $X^2(2)$
Age	6.16	0.05	5.96	0.05	5.96	0.07	7.98**	5.93**	0.03	5.25**
Sex (% girl)	0.60	0.04	0.42	0.06	0.22	0.05	30.4**	4.81**	5.84**	30.4**
Spanish speaking (% Spanish)	0.09	0.04	0.08	0.02	0.07	0.03	0.39	0.02	0.25	0.31
Ethnicity: % European-American	0.35	0.06	0.34	0.04	0.28	0.06	1.02	0.01	0.74	0.77
Ethnicity: % African-American	0.13	0.05	0.23	0.03	0.31	0.06	6.12*	2.43	5.94**	1.43
Ethnicity: % Hispanic/Latino	0.49	0.06	0.34	0.04	0.37	0.06	3.24	3.19	1.65	0.19
Ethnicity: % other	0.04	0.03	0.10	0.02	0.05	0.03	2.68	2.15	0.02	2.17
Percent in home visiting group	0.45	0.064	0.37	0.04	0.43	0.06	1.22	0.90	0.04	0.612

*$p < 0.05$; **$p < 0.001$

Table 4 EF differences by attachment representation latent profile

	Secure profile (S)		Insecure-avoidant profile (A)		Insecure-disorganized profile (D)					
	M	*SE*	*M*	*SE*	*M*	*SE*	Overall $X^2(2)$	S vs. A $X^2(2)$	A vs. D $X^2(2)$	D vs. S $X^2(2)$
DCCS post-switch number correct	4.70	0.19	4.50	0.29	3.91	0.32	4.23	1.72	0.26	4.19*
Corsi task forward condition proportion correct	0.28	0.01	0.25	0.02	0.20	0.02	15.9**	1.95	3.61*	15.8**
Corsi task backward condition proportion correct	0.24	0.01	0.17	0.02	0.14	0.02	20.6**	7.18**	1.17	19.9**
Digit span task forward condition proportion correct	0.34	0.01	0.30	0.01	0.30	0.01	7.77**	4.10*	0.01	6.25**
Digit span task backward condition proportion correct	0.24	0.01	0.18	0.02	0.13	0.02	22.1**	7.31**	2.10	21.35**
HTKS task total correct	38.6	1.42	31.9	2.44	27.0	2.43	17.4**	4.61*	1.91	16.6**

The Bonferroni adjusted $\alpha = 0.02$

*$p < 0.05$; ** $p < 0.001$

the “insecure-avoidant” profile on all tasks (p’s < 0.001), with the exception of the forward condition of the Corsi task and the DCCS task. The “insecure-avoidant” profile performed significantly higher on the forward Corsi task compared to the “insecure-disorganized” profile.

Discussion

In the current study, we explored the interrelations between attachment representations and differences in EF among a sample of children of adolescent mothers. Our results generally indicated, that in accord with our hypotheses, greater executive function performance in early childhood was associated with attachment security rather than attachment disorganization or avoidance.

Classification of Attachment Subgroups

Counter to our initial hypothesis in which we expected to identify four subtypes of attachment, we identified only three subgroups of attachment representations based on the LPA identified patterns of the AFCS codes (secure, avoidant, disorganized) as opposed to four (Reiner and Splaun 2008). The lack of an insecure ambivalent pattern is consistent with previous attachment research both in infancy and childhood, where the insecure ambivalent/resistant category was proportionally smaller than any of the other attachment classifications (Main and Cassidy 1988; Moss et al. 2005; van IJzendoorn and Kroonenberg 1988; van IJzendoorn et al. 1999). Therefore, as we discuss more in the Limitations section, the size of our sample may have precluded us from distinguishing the insecure ambivalent pattern within our LPA model.

The “secure” group was identified based on the concordance of this group’s representation patterns and the predominant definitions of secure attachment (Ainsworth et al. 1978; Solomon and George 2016). In this group, the story stem narratives represented the maternal figure as positive and supportive, and accessible during times of distress; children also acknowledged, as well as appropriately resolved, negative themes and emotions presented in each narrative. Consistent with other research on children with avoidant attachments (Solomon and George 2016), children in the “insecure-avoidant” group represented avoidance of the maternal figure during times of stress, when contact with a secure attachment figure is usually expected to reduce stress. Moreover, when compared to the “secure” group, these children were more likely to avoid negative themes and emotions, and also less likely to resolve them (i.e., by reducing the negative emotions while concluding the story). Attachment theory and research highlights that individuals with avoidant attachment strategies deactivate or inhibit strong negative emotional states (Berlin and Cassidy 2003; Shaver and Mikulincer 2007). The insecure-avoidant profile’s difficulty representing and managing negative emotions and themes is in line with prior work depicting that children with avoidant attachments have difficulty managing the internal experience of negative emotions. Children with avoidant representations may recognize but then summarily dismiss emotional responses to strong negative feelings (Solomon and George 2016; Reiner and Splaun 2008). Our results show that children in the “insecure-avoidant” group portrayed the maternal figure in the story as moderately supportive and minimally rejecting while also engaging in minimally dysregulated narrations, keeping the attachment system deactivated.

We labeled the third group as “insecure-disorganized” because the attachment representations demonstrated in the story stem narratives were markedly incoherent—a hallmark of attachment “disorganization” (Main and Solomon 1990; Solomon and George 2016). Children in this group simultaneously depicted a moderately supportive yet highly rejecting maternal figure, while also portraying the highest overall attachment avoidance. A key marker of “disorganized” attachment representations is high levels of chaotic, violent, and potentially fatalistic narrative story content (Solomon and George 2016). Children within the “insecure-disorganized” group scored the highest on the dysregulation subscale compared to the other two groups. These children tended to have narratives marked my themes of multiple catastrophic events, continued harm to the main story characters, or had stories marked by murder. Additionally, they were less likely than the other groups to resolve the negative themes and emotions, which falls in line with research that depicts overall low emotion regulation among children classified as “insecure-disorganized” (e.g., Kerns et al. 2007).

Considering the distribution of attachment representations within the sample, the majority of children were classified as having “insecure” representations. This distribution of attachment classifications is in line with other work done in similar samples experiencing socioeconomic and relational adversity. For instance, a meta-analysis conducted by Cyr et al. (2010) showed that the experience of socioeconomic adversity led to higher classifications of insecure attachment patterns in comparison with low-risk samples which had higher classifications of secure attachment. Other work examining the sample of children and families in this study has shown high rates of residential instability, difficulty covering financial expenses, and trauma (Easterbrooks et al. 2017; TIER 2015). Further, studies conducted in samples of children of adolescent mothers find higher rates of insecure-disorganized and insecure-avoidant attachment classifications, in comparison with samples of children of non-adolescent parents (e.g., Madigan et al. 2006).

EF Differences by Subgroup

Results from our analyses investigating differences in the three attachment groups across EF tasks provided support for our initial hypotheses regarding connections between attachment and EF and showed that in general, EF results favored the "secure" group, then the "insecure-avoidant" group, while the "disorganized" group tended to perform worse overall. These patterns are consistent with the attachment literature examining associations between attachment security and other aspects of cognition, for example, general cognitive development assessments in early childhood or school achievement test scores. For instance, prior work depicts higher performance on assessments of general cognitive performance among children classified as having "secure" attachment representations (e.g., Spieker et al. 2003). Moreover, consonant with our findings, other studies show the lowest cognitive performance among children classified as "insecure-disorganized" (e.g., O'Connor and McCartney 2007). Our work extends this pattern of findings to another aspect of cognition, EF. More nuanced details about the above-mentioned patterns of EF performance among the different attachment classification are discussed further in the following paragraphs.

The "secure" group's higher EF abilities may be explained by understanding the patterns of care associated with "secure" and "disorganized" attachments. Secure attachment behaviors and representations are often associated with receiving sensitive and responsive care in early childhood (de Wolff and van IJzendoorn 1997). Moreover, consistently sensitive and responsive care is related to more optimal EF performance, as mediated by the down-regulating of the stress response (Bernier et al. 2012). Thus, attachment and EF may be linked through parenting processes that are related to both. In addition, stress has significant impact on the structure and function of the prefrontal cortex (PFC), the part of the brain that is critically involved in EF (Arnsten 2009). Disorganized attachment representations typically are associated with highly stressful early life experiences, which are also linked with impairments of cognitive systems, such as EF, through a chronically activated stress response system (Bernard and Dozier 2010). Attachment disorganization and problems with EF may emerge, in part, from parenting that fails to modulate child stress, through behaviors such as parental dissociation, a hostile-helpless stance, and frightening interactions (Benoit 2004; Lyons-Ruth et al. 1999). The chronic activation of the stress system can alter brain circuitry, impacting developing systems such as those implicated in EF (Fox et al. 2010). For instance, chronic stress may negatively affect by shifting attention from new learning and processing to the fight-flight-freeze responses associated with stress activation. Thus, the "secure" group's higher performance on EF tasks is consistent both with empirical and theoretical understandings of attachment and EF.

Support for our hypothesis that children with secure attachment representations would outperform those with avoidant representations was evident on most EF tasks. These findings match other research reporting mixed results when exploring the differences in cognitive tasks involving components of EF between children with avoidant and secure attachments (e.g., Granot and Mayseless 2001; Stievenart et al. 2011). Shaver and Mikulincer (2007) posited that avoidant attachment styles can interfere with problem-solving because these individuals may not be open to reappraisal and new knowledge that challenge their beliefs, making it "less likely that will be integrated into their cognitive structures and that they will use them effectively in information processing" (p. 452). Examining the context of the research protocol may explain the differences between the "insecure-avoidant" and "secure" groups. Given that "insecure-avoidant" children performed similarly to "secure" children with certain tasks, one hypothesis could be that when "insecure-avoidant" children were more comfortable with the experimenter, within the research protocol, the differences in attachment representations appeared to have minimal effects.

However, initially interacting with an unfamiliar adult experimenter who is asking about stressful and negative events (e.g., the child getting hurt, disobeying mother, home intruder) may have served as emotionally arousing to "insecure-avoidant" children. Based on early cognitive representations (e.g., the "internal working model") of relational experiences within a care setting, children with "avoidant" representations may experience overwhelming autonomic arousal within relational contexts (Mikulincer et al. 2003). Therefore, an avoidant representation may be priming children's autonomic response in relational contexts, such as in interactions with the adult experimenter during the EF tasks. In turn, children with secure attachment representations may outperform those with avoidant representations given that "insecure-avoidant" children have to negotiate both the cognitive load of a heightened stress response as well as participation in tasks that are demanding for EF systems.

Although the mean scores on all EF tasks were generally higher for the avoidant compared to the disorganized group, and consistent with what attachment theory would predict, counter to initial hypotheses, we only found one significant difference (on the Corsi task assessing working memory) between these groups on EF. These findings are similar to other work that failed to detect significant differences or only detected marginal effects on performance in tasks involving facets of EF among children with avoidant versus disorganized attachments (Granot and Mayseless 2001; Jacobsen et al. 1994). Studies that compared the performance of children with insecure-avoidant and insecure-disorganized representations on such tasks found small differences among groups—with children showing insecure-avoidant behaviors or representations scoring higher (Granot and Mayseless 2001; Jacobsen et al. 1994). Our study corresponds to this prior work. It may be that both of these groups of children with insecure attachments struggle (though perhaps somewhat differently) with managing stressful circumstances in an adaptive manner.

Furthermore, in a recent literature review, Granqvist et al. (2017) suggest that pathological behaviors commonly thought to be associated with a disorganized attachment may, in fact, be due to other adverse life contexts rather than solely from the quality of the attachment bond, suggesting that there may be multiple influences and pathways involved in the parenting, attachment, and EF connections (DeRuiter and van IJzendoorn 1993). In this regard, without accounting for other life circumstances, a child's insecure-disorganized attachment representation may not in and of itself place a child more or less at risk for pathology than a child displaying another subtype of insecure attachment representation. Moreover, Green and Goldwyn (2002) noted that it remains unclear whether the impacts of attachment disorganization reach beyond relational domains into the cognitive realm. As discussed earlier, prior work in this sample has depicted high rates of maternal trauma and other adverse circumstances (Easterbrooks et al. 2017; TIER 2015). The fact that children with representations characterizing both insecure classifications were likely experiencing the same adverse circumstances may in part explain the minimal differences between both groups on EF performance.

Strengths and Limitations

Although prior research has either explored the relations between different attachment classifications and EF in low-risk samples or continuous measures of attachment and EF in high-risk samples (e.g., Bernier et al. 2015; Meuwissen and Englund 2016) to our knowledge, our study is among the first to examine the associations between attachment representations and children's EF in a high-risk sample. Both attachment representations and EF skills were measured directly from children and were not limited by self-report methodologies. However, the cross-sectional nature of the data is a limitation of this study, as is the fact that only three of the four original patterns of attachment were represented (we did not find an insecure ambivalent pattern). Both attachment representations and EF task performance were assessed at the same time point. Future work examining the associations between attachment representations and EF skills may consider using longitudinal designs to parse out predictive relations. In addition, despite the fact that children's attachment typologies and cognitive representations incorporate the quality of early caregiving experiences (Bretherton 1990), we did not have data on the quality of early caregiving of children which may have served to further validate the attachment classifications as well as to explore the possibility that parental sensitivity may mediate the relations between attachment representations and EF. Though prior studies have validated attachment representations with the quality of early care received (Splaun et al. 2010), future studies may consider further validation of attachment representations with patterns of early care in addition to the potential mediating effect of parental sensitivity on EF.

Another limitation of our study is that we were not able to represent all four of the original attachment patterns within our sample. Specifically, we were not able to identify an "insecure-ambivalent" pattern. However, within meta-analyses of attachment patterns, "insecure-ambivalent" attachment representations tend to be less common than other attachment patterns (Broussard 1994; van IJzendoorn et al. 1999). Moreover, researchers have commented on the limitations of representational measures of attachment, such the MSSB, in discerning differences in the specific type of insecure classification (Solomon and George 2016). In addition, our study sample may have been too small to capture the two separate insecure classifications. For instance, given the fact that the classification precision, as assessed by the entropy value, was higher for a two-class specification, than that of the three-class specification, the LPA model may have been unable to distinguish between the "insecure-avoidant" and "insecure-ambivalent" classifications.

An additional potential limitation to our study is the fact that the EF tasks were interactively completed within an adult interviewer, As may be the case with certain patterns of attachment (e.g., avoidant and disorganized) interactions in a relational context may induce autonomic arousal which could in turn impact task performance in a negative fashion (Bernard and Dozier 2010). However, as the overall aim of this work was to elucidate the concurrent associations between attachment and EF, it is important to consider EF performance in a holistic sense. For example, self-regulatory skills are comprised not only by cognitive processes like EF but also by affective systems and are implicated in social interactions (Blair and Diamond 2008). By using EF assessments delivered in a relational manner, our results may shed light on how EF differences among children with different attachment representations can manifest in social contexts.

Implications and Conclusions

This study is among the first to examine the relations between attachment representations and EF within a sample of children experiencing adversity. Our findings showing that attachment security was linked with better EF performance underscore how secure attachment representations may be beneficial for overall socio-emotional and behavioral functioning (Drake et al. 2014; Gilliom et al. 2002). Research has demonstrated that attachment bonds can change towards greater security with changes in environmental context and support (e.g., Bernard et al. 2012). Accordingly, our study suggests the need for additional research on intervention and prevention initiatives that support the development of secure attachments in tandem with optimal EF. One interpretation of the link between secure attachment representations and higher EF in our study suggests that interventions that foster parents' abilities to respond sensitively and responsively to their children early in life also will prove beneficial to children's acquisition of both secure attachment representations and executive function as they navigate the early childhood years.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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