HHS Public Access
Author manuscript
J Abnorm Child Psychol. Author manuscript; available in PMC 2021 September 01.

Published in final edited form as:
J Abnorm Child Psychol. 2020 September ; 48(9): 1115–1128. doi:10.1007/s10802-020-00671-2.

Moderating the risk for Attention deficits in children with pre-adoptive adversity: the protective role of shorter duration of out of home placement and children's enhanced error monitoring

Tahl I. Frenkel[1], **Bonny Donzella**[2], **Kristin A. Frenn**[2], **Sofie Rousseau**[1], **Nathan A. Fox**[3], **Megan R. Gunnar**[2]

[1]Ziama Arkin Infancy Institute, Baruch Ivcher School of Psychology, Interdisciplinary Center (IDC), Herzliya, Israel

[2]Institute of Child Development, University of Minnesota, Minneapolis, United States

[3]Department of Human Development and Quantitative Methodology, University of Mxyaryland, College Park, USA

Abstract

Early institutional-deprivation has been found to increase risk for inattention/hyperactivity (ADHD). Notably, studies suggest that children with a history of adversity evidencing an enhanced ERP (the error-related-negativity; ERN), may be protected against attention problems. However, such protective effects of the ERN have been studied in children whom typically experienced residential instability. It is unknown whether error-monitoring is similarly protective for children with stable post-deprivation placements. The present study examined the protective effect of the ERN in a sample of children who experienced at least 3-years of stable, relatively enriched caregiving after being internationally-adopted as infants/toddlers from institutional-care. We included two groups of children adopted internationally before age three, one group adopted from institutional-care (PI:*n*=80) and one comparison group adopted from foster-care (FC;*n*=44). A second comparison group consisted of non-adopted children (NA;*n*=48) from demographically comparable families. At five-years of age, we assessed child ADHD symptoms (parent-report) and behavioral performance and neural correlates of error-monitoring (Go/No-Go task). PI children displayed lower Go/No-Go accuracy relative to FC children, and higher levels of ADHD symptoms relative to NA controls. In both FC and PI groups, longer duration of pre-adoptive out-of-home placement was associated with inattention, especially for children with deficits in error-monitoring. Enhancing cognitive control in the form of error monitoring might be a useful

---

Corresponding author: Megan R. Gunnar, gunnar@umn.edu; Phone: 612-624-2713; Fax: 612-624-6373; Institute of Child Development, University of Minnesota, 51 E. River Road, Minneapolis, MN 55455.

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

Ethical considerations
All parents were re-consented at the beginning of each research session and the study was approved by the institutional review board of the University of Minnesota.

intervention target to protect children from some of the negative outcomes associated with adverse early care. Furthermore, results underscore that regardless of type of pre-adoptive care, we should aim to place children in stable/permanent homes as early as possible.

Keywords

event-related potentials; error-related negativity; ADHD and externalizing symptoms; institutions; foster-care; adoption

---

Families in the United States are annually adopting approximately 4000 children from foreign countries (U.S. Department of State 2018). This is a decrease from peak years in the mid 2000's when as many as 20,000 children were entering the American families, often having experienced institutional (e.g., orphanage) care prior to adoption. Many of these children were found to be at risk for Attention Deficit/Hyperactivity Disorder (ADHD) or to have symptoms in the preclinical range (Gunnar and Van Dulmen 2007, Hawk and McCall 2011). ADHD symptoms are one of the deprivation specific deficits identified by Rutter and colleagues in their work on children adopted from Romania in the early 1990's (Kreppner et al. 2001, Rutter et al. 2001, Rutter et al. 2010). They noted that post-institutionalized children who exhibited problems with attention regulation were at heightened risk for developing psychopathology with age (Colvert et al. 2008, Sonuga-Barke et al. 2017, Stevens et al. 2008). More recently, in the Bucharest Early Intervention Project (BEIP), global deficits in executive function, of which attention regulation forms a core, have been shown to be a transdiagnostic mediator between institutional deprivation and psychopathology in adolescence (Wade et al. 2019).

Given the increased risk for problems regulating attention in children with histories of institutional care, it is not surprising that these children have also been found to exhibit associated deficits in behavioral measures of cognitive control (Hostinar et al. 2012, Loman et al. 2013, McDermott et al. 2013, Pollak et al. 2010). Additionally, neural correlates of these deficits such as Event-related potentials (ERPs), including the ERN a frontocentral negative deflection in the ERP that peaks within 100ms following an errant response, also indicative of response conflict, response monitoring and particularly error monitoring (ERN - Falkenstein et al. 2000, Gehring et al. 1993; Hajcak 2012), have been found to be adversely associated with early institutional care (Loman et al. 2013, McDermott et al. 2012). Importantly, children with a history of institutional deprivation who also exhibited problems in error monitoring were more likely to exhibit externalizing problems and ADHD symptoms at age 8 years (McDermott et al. 2013) and again at 12 years (Troller Renfree et al. 2016). More specifically, in both instances the magnitude of the ERN moderated the effect and appeared to buffer deprivation related risk, such that only those with smaller ERNs showed the impact of early institutional care on attention and behavior regulatory problems, while other children did not. Importantly, while McDermott et al (2013) assessed the moderating effects of the ERN on a broad composite which combines both Externalizing and ADHD symptoms, Troller-Renfree et al., (2016) examined separate effects of the ERN on Externalizing and ADHD, and even further separated between Impulsivity and Inattention symptoms which together comprise the ADHD scale. Findings revealed associations between the ERN and externalizing symptoms, as well as impulsivity, but not inattention (Troller-Renfree et al., 2016) – thus pointing toward the importance of examining each of these scales separately.

Interestingly, at 12 years of age longer duration of institutional care was identified as a particularly important risk factor which was moderated by magnitude of the ERN (Troller Renfree et al. 2016). It is notable that many of the children in the BEIP study, by the time of these assessments, were no longer in their assigned conditions and had experienced significant residential instability in addition to early institutional care. Thus it is not clear whether increased risk for ADHD in this sample is due to the high levels of social deprivation typical of institutional care per se (i.e. *type* of care), or to the post-deprivation residential instability. Likewise, while cognitive control, indexed by the ERN, was a significant moderator of risk in previous samples, we do not know whether cognitive control is as important a protective factor for children who experienced stable and supportive placements after removal from early deprivation. In other words, it is unclear whether individual differences in error monitoring would have a similar predictive and moderating influence in children with *stable post-deprivation placements*. Indeed, previous findings suggest that post-deprivation stability may influence neural indices of cognitive control. In a study of children in foster care, those randomly assigned to receive an intervention designed to provide more stable, supportive care by foster families exhibited a larger feedback related negativity indexing cognitive control at age 5 years, than those without the intervention (Bruce et al. 2009). Thus it is possible that a more stable, supportive placement will improve cognitive control for previously deprived children, thus changing the predictive power and overriding the moderating role of measures like the ERN. Alternatively, it might be that even when children have achieved a stable and supportive home, individual differences in cognitive control will still buffer deprivation related risk and thus moderate between early deprivation and later problem behavior. If so then it might be reasonable to focus on improving cognitive control skills in children with histories of early deprivation and neglect, regardless of whether they move into stable placements or experience residential instability in foster care or other alternative care arranagements.

In sum, the above described role of the ERN in buffering between early deprivation and later problem behavior has been previously studied only in samples of children removed from institutions and placed in foster care. These studies have included children older than those assessed here, many of whom had histories of post-placement residential instability (McDermott et al., 2013; Troller Renfree et al., 2016). The present study is the first to investigate whether individual differences in child ERN might moderate the extent to which early adversity predicts child outcome in the context of early adoption with stable placements. The present study included three groups of children (children adopted internationally from institutional care by the age of three; children adopted internationally from foster care; and non-adopted children born and raised in their birth families). The children adopted from foster care served as an adoption comparison group to help control for conditions that result in children being abandoned or removed from their families. Specifically, the foster group differs from the post-institutionlized group only in *type* of care, however is equivalent to the post-institutionalized group in that these children also experienced degrees of early care disruptions and loss and comparably high levels of pre-adoptive residential stability.

The present study design allowed us to investigate the effects of two aspects of early adversity; type of care indexed by group, and duration of out of home placement prior to stable placement in adoptive families. We examined associations between these measures of early adversity and children's symptoms of ADHD and externalizing behaviors as reported by parents, as well as child response monitoring indexed by the ERN during a Go/No-go task. Assessments were completed when children were 5 years of age, allowing us to examine whether deficits in attention would still be evident after children had experienced at least 3-years of stable, supportive post-adoptive caregiving environments which are relatively enriched compared to their pre-adoptive care. In addition, we investigated whether the links between early adversity and children's ADHD and externalizing symptoms was moderated by individual differences in child error monitoring. In line with the few past studies on error monitoring, ADHD, and externalizing symptoms in children with a history of early institutional care (Loman et al., 2013; McDermott et al., 2012; McDermott et al., 2013; Troller- Renfree et al., 2016), we hypothesized that:

1. Compared to nonaadopted controls, children adopted with institutional histories would show deficits in cognitive control and error monitoring indexed by poorer behavioral performance and smaller ERN amplitude on a Go/No-go task.

2. Compared to children with institutional histories, children adopted internationally from foster-care, who had experienced less social deprivation, would perform better than post-institutionalized children.

3. Finally, we predicted that our indices of early adversity would be associated with symptoms of ADHD and externalizing problems at age 5, and that, additionally, this association would be particularily strong for children with deficits in error monitoring as indexed by the ERN. Importantly, given the high comorbidity between impulsivity and inattention, effects of the ERN have commonly been assessed and observed on overall ADHD scores, which are comprised of Impulsivity and/or Inattention symptoms. Given the fact that previous research points toward potential differential effects of ERN on each of these symptoms (for meta-analysis see Pasion and Barbosa, 2019), we opted to examine the Impulsivity and Inattention scales separately. While prior research on the ERN and ADHD has most often revealed associations with Impulsivity, few studies also found specific effects on Inattention (For review see Johnstone, Barry & Clark., 2013; For meta-analyses see Paison & Barbosa., 2019). Thus, hypotheses regarding the potential differential effects on each of these subscales were exploratory.

Methods

Participants

The sample comprised 172 children taking part in a longitudinal study following child adoption into families after experiencing early institutional care. The 172 participants included three groups: 80 children that were internationality adopted from institutionalized care (post institutionalized; PI; 45 Female); 44 children that were internationally adopted from foster care with little to no institutional deprivation (FC; 16 Female); and 48 children reared in birth families of the same education and income as the adoptive families who served as a non adopted comparison group (non-adopted; NA; 23 Female). PI children were 16–36 months old at adoption and were recruited into the study within the first months following adoption. FC children were adopted by approximately 1-year of age, consistent with what is typical for international adoption from countries using foster care for wards of the state. In addition, typical for international adoption, none of the adoptive home-based placements were kinship in either the PI nor the FC samples. Nonadopted children were recruited through department-maintained participant registry of families interested in research, which sends letters to all families in the area that recently welcomed a newborn. The education and income of families on this list tend to be high and roughly comparable to that of international adoptive families. Inclusion in the NA sample required that children would be reared in their families of origin within normative caregiving environments. Children were recruited at the age of 18 to 36 months and the sample was drawn so that it would be roughly comparable (i.e., not significantly different) to the PI an FC sample in both child age and sex. PI children were adopted from an institutional care setting with little to no foster-care prior to adoption, (*M*=77.00% of life in institutional care; duration *M*=18.59 months, *SD*=7.92; 98% had zero foster-care). FC children were adopted from foster-care settings with little to no institutional-care prior to adoption, (*M*=88.02% of life in foster care; duration *M*=7.91 months, *SD*=1.78; 44.44% had spent less than 2 weeks in any kind of an institution, including hospital nursery). The majority of PI children (83.33%) and FC children (86.36%) resided in 2 to 3 different caregiving settings prior to adoption.

In order to ensure that the nonadopted sample would serve as a comparision group reflective of normative development, children with atypical developmental experiences or childare-related adversity were excluded (e.g. childhood maltreatment, syndromes, congenital disorders, severe health problems). Remaining children were included in data analyses if they had enough available data. As such, 36 children were excluded from analyses due to the following exclusion criteria: suspected prenatal alcohol exposure (9 PI, 2 FC; as screened using the FAS Facial Photographic Analysis software; (Astley and Clarren 2000); congenital disorders (2 PI, 1 FC); maltreatment (1 NA), autism (1 NA), childhood cancer (1 NA); and no usable ERP or parent report data at any of the assessments (13 PI, 5 FC, 4 NA).

Demographic data for each of the groups are displayed in Table 1. Of the 172 participants, 171 participants had data on the internalizing scale, 168 on the externalizing scale, and 170 on the ADHD scale. Within the PI group, 75 participants (93.75%) had data on age of separation from birth parents, and all 80 participants (100.00%) had data regarding age of child placement in the adoptive home. Within the FC group, 43 participants (97.72%) had data on age of separation from birth parents, and all 44 participants (100.00%) had data regarding age of child placement in the adoptive home. 164 participants had behavioral data on the Go/No-go task and 159 participants had ERP data; however children with less than 40% accuracy on Go trials or fewer than 8 artifact-free trials in ERP waveforms locked to erred no-go responses were excluded, yielding behavioral data on 163 participants, and ERN/CRN data on 104 participants. Previous research has indicated that the ERN becomes internally consistent from 8 trials onward (Olvet and Hajcak 2009, Pontifex et al. 2010). We examined internalizing, externalizing and ADHD symptoms for those excluded because of insufficient ERP trials and poor accuracy. The results showed that children who were excluded because of insufficient ERP trials had significantly lower ADHD symptoms than non-excluded children ($t(155)=-2.26$; $p = 0.025$). Follow-up analyses indicated that overall, excluded children made less NoGo errors ($t(152)= 4.35$; $p < 0.001$) and therefore had insufficient ERN ERP trials. No other significant between-group differences were observed (p's > 0.300).

Procedure

Performance on the Go/No-go task and simultaneous EEG data were collected at a session occurring approximately three years after the PI children's arrival into their adoptive home (PI time since arrival M=36.54 months, SD=4.71), when children in all three groups were 5–5.5 years of age (M age=62.18 months, SD=2.15). Parents observed via camera in an adjacent room and reported on child behavior problems. All parents were re-consented at the beginning of each research session and the study was approved by the institutional review board of the University of Minnesota.

Go/No-go ERP task

The Zoo Game (Lamm et al. 2012). A modified version of the Zoo Game was used, presenting only neutral animal pictures. The current task consisted of 75% go trials and 25% no-go trials, presented within two blocks of 140 trials. Prior to completing the two blocks, children completed 12 practice trials. To increase children's motivation to participate, animal pictures were used in this task rather than the traditional stimuli of letters. Children were asked to help a zookeeper recapture escaped animals with the help of a baby orangutan referred to as the 'monkey'. To recapture the animals, children were told to respond via button-press (as fast and accurate as possible) as soon as they saw an animal on the screen (go trial) unless it was the 'monkey' (no-go trial). Animal stimuli were presented on the screen for 500ms, followed by a black screen for 900ms or until the child responded. The inter-trial interval was jittered between 200–300ms. Images were presented on a 17-in monitor using E-prime Software (Psychology Software Tools, 2002).

EEG data collection and ERP processing

EEG was recorded using a 128-channel HydroCel Geodesic Sensor Net and sampled at 500 Hz, using EGI software (Net Station 4.4; Electrical Geodesic, Inc., Eugene, OR). Once the impedance values were reduced to below 100 kΩ, data acquisition began. During recording, all channels were referenced to Cz and after acquisition, data were re-referenced to an average reference. Data were filtered offline using an FIR bandpass filter 0.3Hz to 40Hz. Next, an automated procedure was used for artifact rejection. Eye blink artifact thresholds were set to 160μV (peak-to-peak) and all trials in which this threshold was violated were excluded from analyses. Signal activation change (peak-to-peak) exceeding 180μV across the entire segment and fast transits exceeding a difference (peak-to-peak) of 60μV were marked as bad. Channels were marked globally bad if the channel was bad on greater than 80% of the trials. Trials were marked bad if more than 15% of the channels were determined to be bad. Bad channels on the remaining good trials were interpolated.

We segmented response-locked waveforms for correct go and incorrect no-go trials into epochs from 300 ms before to 450 ms after the response. Correct and error trials were separately averaged for each participant and were baseline corrected to the average activity from 200 ms to 100 ms before the response. The response-locked error-related negativity (ERN) and correct response negativity (CRN) were between −50 to 50ms post-response at mediofrontal electrodes (Cz, FCz, 7, 106) where ERN and CRN activation reached maximal negativity (see Figure 1 for Sensor Net Layout). Average activation for error (ERN) and correct (CRN) trials, across electrodes, were exported for these time windows.

Measures

Behavioral performance on the Go/No-go task—Accuracy was calculated separately for go and no-go trials, as the number of correct trials divided by the total number of trials. Reaction times were averaged separately for correct trials and error trials and did not include nonresponse trials.

Child psychopathology symptoms—Child psychopathology symptoms were assessed using the MacArthur Health and Behavior Questionnaire (HBQ; Parent version for Middle Childhood; Boyce et al. 2002, Essex et al. 2002). The primary caregiver (93.60% mothers) completed the HBQ (3-point Likert scale) at the age 5–5.5 year assessment to reflect child behavior in the last 6 months. Reliability in the present sample was: internalizing α=.81, externalizing α=.87, ADHD α=.90.

Measures of early adversity—Group membership (PI, FC, NA) was used as an index of type of early life adversity. *'Duration of exposure to out-of-home placement'* (i.e. Duration) was calculated by subtracting 'age of child separation from birth parents' from 'age of child adoption'. This measure was calculated for children in the FC and PI groups. While we do not have observational data regarding the exact extent of adversity experienced in each of these pre-adoptive caregiving settings, we do have some information regarding pre-adoptive experiences. These data were mostly available for the PI parents many of whom had the opportunity to see the institutions prior to adoption. For the PI parents, 11.30% reported suspected physical abuse, 22.50% severe neglect and 42.52% suspected malnutrition at some point prior to adoption. At their first medical exam in the US, 10.00% reported the child had parasites and 11.32% reported the child was anemic. A trained social worker with a career in international adoption conducted a semi-structured interview with the primary parent within the first year following adoption. Information was collected regarding the number of transitions in caregiving settings prior to adoption, as well as descriptive information regarding the quality of physical and social caregiving that the child received in pre-adoptive settings. The average rating for both physical and social care was 2.93, which translates into between average and poor. Taken together, pre-adoptive caregiving settings appear to be relatively adverse environments, thus, "duration of exposure to out-of home placement" was assumed to be a proxy for duration of adversity. Duration effects were examined across both FC and PI children together (collapsed across both groups), yielding effects of duration regardless of type of adversity.

Data analytic plan

Preliminary analyses to determine covariates examined correlations between study variables and participants' age; sex; number of artifact-free trials in ERP waveforms locked to erred No-Go responses; and number of artifact-free trials in ERP waveforms locked to correct Go responses. Covariates were included based on significant associations identified in these preliminary analyses. Importantly, for each analysis investigating the effect of group, posthoc analyses comparing PI and FC groups were controlled for duration. Moreover, duration effects were always controlled for group effects. Because duration was calculated only for PI and FC children children in the NA group were excluded from analyses examining duaration effects.

For our main analyses, we first examined the effects of early adversity on child psychopathology symptoms. Group effects on child symptoms were explored via ANCOVA analyses. Duration effects on child symptoms were explored via regression analyses (collapsed across both PI and FC groups) and the interactive influences of Group and Duration on Child symptoms were examined by moderation analyses.

Second, repeated measures analyses were employed to examine effects of early adversity on (a) accuracy; (b) reaction time and (c) neural correlates of response monitoring (ERN and CRN) during the Go/No-Go task. For each of these outcomes, we first examined within subject effects of Trial Type. We then added either Group or Duration as a between subjects factor to examine Group effects and Group X Trial Type effects, or Duration effects and Duration X Trial Type effects respectively. Finally, we examined interactive influences of Group *and* Duration in predicting each of the 3 outcomes (Trial Type was included as a within subject factor and Group and Duration as between subjects factors).

Lastly - a series of moderation analyses were conducted to examine whether error-monitoring might moderate the effects of Duration on child internalizing, externalizing and ADHD symptoms (including separate examination of the Impulsivity and Inattention subscales) – and whether these duration effects might be moderated by *type of adversity* (i.e. Group; PI=0 and FC=1). All moderation models were run using bias-corrected bootstrap sampling over 5000 iterations (Hayes 2009). For all analyses, potential covariates (child Sex; child Age at assessment; number of artifact-free trials in ERP waveforms locked to erred No-Go responses; number of artifact-free trials in ERP waveforms locked to correct Go responses; number of pre-adoptive care settings) were controlled for if they were significantly associated with the independent, dependent, and/or moderator variable in the model. However, in order to limit bias due to power, covariates with nonsignificant contribution to the specific model were removed.

Analyses were conducted using IBM SPSS Version 24.0 (IBM Corp, Armonk, NY) – including the add-on PROCESS macro for conditional analyses (Hayes 2017). All statistical comparisons were corrected by means of the Least Significant Difference method. In addition, power analyses were performed. More specifically, given an estimated medium effect size of $F^2 = 0.15$, alpha of 0.05, and power of 0.8, an overall sample size of n = 77 was needed for our most complex analysis of moderation. For all analyses, Little's MCAR test was non-significant (p's > 0.095), indicating that data was missing completely at random.

Thus, missing data could be handled by means of listwise deletion. Importantly, after listwise deletion, sufficient sample size remained for all analyses, suggesting that listwise deletion will not introduce biased parameter estimates and pointing toward listwise delation as the preferred method of handling missing data (Allison, 2003).

Results

Preliminary analyses examined correlations among all study variables, as well as associations between study variables and participants' age; sex; number of artifact-free trials in ERP waveforms locked to erred No-Go responses; and number of artifact-free trials in ERP waveforms locked to correct Go responses (see Table 2 and 3).

Associations between early adversity and child symptoms

As expected, Univariate ANCOVAs revealed significant Group differences in the ADHD symptoms scale, ($F(2,166)=5.67$, $p=0.004$, $\eta 2p=0.06$). Fisher's LSD indicated that PI children, ($M=0.83$, $SE=0.04$), had heightened ADHD symptoms relative to NA children, ($M=0.59$, $SE=0.05$, $p=0.001$), but not FC children, ($M=0.73$, $SE=0.06$, $p=0.176$). The difference between FC and NA was not significant, ($p=0.088$). Next, we separately investigate the impulsivity and inattention subscales. Significant differences were found for both impulsivity ($F(2,166)=4.38$, $p=0.014$, $\eta 2p=0.05$; PI>NA; $p=0.004$) and inattention ($F(2,166)=5.57$, $p=0.005$, $\eta 2p=0.06$; PI>NA; $p = 0.001$; See Figure 2). No group differences emerged for the Externalizing or Internalizing symptoms scale (ps = 0.138 and 0.399 respectively). Finally, no Duration or Group by Duration interaction effects were found for symptoms of ADHD (ps = 0.083 and 0.578), internalizing problems (ps = 0.872 and 0.280), or externalizing problems (ps = 0.405 and 0.796).

Associations between early adversity and behavioral performance on the Go No-Go Task

Accuracy—In the first model, as expected, a main effect of trial type was revealed, such that mean accuracy was higher for Go than for No-go trials across Groups, ($F(1,161)=266.29$, $p<0.001$, $\eta 2p=0.62$). In the second model, a main effect of Group emerged, ($F(2,159)=3.99$, p=0.020, $\eta 2p=0.05$). Pairwise comparisons revealed that FC children displayed greater accuracy ($M=0.72$, $SE=0.02$) than PI children ($M=0.67$, $SE=0.01$, $p=0.006$). No significant difference emerged between NA and either PI or FC children (p's>0.156). No Group by Trial type interaction was observed ($F(2,159)=1.96$, $p=0.145$). In the third model, neither a main effect of Duration ($F(1,107)=0.04$, p=0.850, $\eta 2p=0.00$), nor an interaction effect of Duration by Trial type ($F(1,107)=0.51$, p=0.477, $\eta 2p=0.01$) was observed. In the fourth model, neither an interaction effect of Group by Duration ($F(1,106)=5.54$, p=0.122, $\eta 2p=0.02$), nor an interaction effect of Group by Duration by Trial type ($F(1,106)=0.02$, p=0.888, $\eta 2p=0.00$) was observed.

Reaction time—In the first model, as expected, repeated-measures analyses revealed a main effect of trial type such that children were slower for correct Go than for incorrect no-go trials, ($F(1,160)=296.76$, p<0.001, $\eta 2p=0.65$). In the second model, no main effect of group was revealed ($F(2,158)=0.59$, p=0.553, $\eta 2p=0.01$), however a significant Group by Trial-type interaction emerged, ($F(2,158)=3.08$, p=0.049, $\eta 2p=0.04$) suggesting that Group differences were stronger in No-go relative to Go trials, yet follow up analyses failed to reach significance. In the third model, neither a main effect of Duration (F(1,108)=0.09, p=0.771, η2p=0.00), nor an interaction effect of Duration by Trial type (F(1,108)=3.26, p=0.074, η2p=0.03) was observed. In the fourth model, neither an interaction effect of Group by Duration (F(1,106)=0.15, p=0.698, η2p=0.00), nor an interaction effect of Group by Duration by Trial type (F(1,106)=0.00, p=0.987, η2p=0.00) was observed.

Associations between early adversity and neural correlates of response monitoring (ERN, CRN) during the Go No-Go Task

In the first model, as expected, results revealed a main effect for Trial-type (F(1,103)=46.54, p<0.001, η2p=0.31) such that ERP amplitude was more negative for incorrect No/Go (M_{ERN}=0.01, SE=4.01) than correct Go trials (M_{CRN}=1.83, SD=3.15). In the second model, the main effect of Group (F(2,101)= 5.52, p=0.085) and the effect of Group by Trial-type (F(2,101)=0.26, p=0.772) failed to reach significance. Figure 3 depicts the ERN and CRN waveforms by Group. In the third model, neither a main effect of Duration (F(1,71)=0.09, p=0.762, η2p=0.00), nor an interaction effect of Duration by Trial type (F(1,71)=2.17, p=0.145, η2p=0.03) was observed. In the fourth model, a Group by Duration interaction effect emerged (F(1,70)=5.15, p=0.026, η2p=0.07) such that PI children had generally less negative ERN and CRN amplitudes, regardless of Duration whereas for FC children longer Duration was associated with less negative ERN and CRN amplitudes. No Group by Duration by Trial type interaction effect was observed (F(1,70)=0.46, p=0.500, η2p=0.01).

Moderating effects of error-monitoring on links between duration of out-of-home placement and ADHD Symptoms

In the group of children with PI or FC background (i.e., NA children were excluded), we assessed whether neural correlates of error monitoring moderated the association between Duration and ADHD, including separate examination of the Impulsivity and Inattention subscales, as well as Internalizing, or Externalizing symptoms. In addition, we investigated whether the effects were specific to type of out-of-home care, by adding group (PI, FC) as a second moderator (hence assessing a moderated moderation model). A first important observation was that none of the interactions were significantly moderated by group (p's>0.122), meaning that all results detailed below apply to the entire “early adversity” sample (both PI and FC children), regardless of type of adversity.

ERN amplitude did not significantly moderate the association between Duration and ADHD symptoms (β=0.00, t=1.90, p=0.061). However, further analyses revealed moderating effects which were specific to the inattention subscale. Specifically, while the interaction between ERN amplitude and Duration did not significantly predict impulsivity (p=0.306), it did significantly predict inattention (β=0.00, t=2.36, p=0.021). Follow-up simple slope analyses revealed that when children exhibited deficits in error monitoring indexed by small (less negative) ERNs, longer Duration was significantly associated with increased inattention, (β=0.02, t=2.33, p=0.023). When ERNs were large (increased negativity), Duration no longer predicted inattention (β=−0.01, t=−1.08, p=0.286) (See figure 4). No significant moderating effects were found for the Externalizing and Internalizing symptoms scale (*p's*>0.111). CRN amplitude did not significantly moderate the link between duration of out-of-home-placement and child ADHD, externalizing, or internalizing symptoms (*p's*>0.295).

Discussion

By including an adoption comparison group of children who experienced foster care rather than institutional care prior to adoption, the present study points to common factors to both groups of children for heightened ADHD symptoms including both heightened symptoms of Impulsivity and heightened symptoms of Inattention. That is, there were no group differences between PI and FC children in ADHD symptoms, yet there were significantly higher levels of ADHD in the PI group relative to the nonadopted comparison sample, and while only a trend level finding, there were also higher levels of ADHD in the FC children relative to the nonadopted controls. In our analyses of cognitive control as a protective factor in the face of ADHD, we thus combined the two adopted groups treating them as an early adversity group. This allowed us to directly examine within that early adversity group, whether longer duration of out of home placement prior to permanent adoption was a risk factor for symptoms of heightened ADHD, (i.e. Impulsivity and /or Inattention). This is the first study to show that the ERN is a protective factor for children experiencing longer periods of time without permanent parents early in life. Furthermore, this is the first study to show the protective role of the ERN in reducing the likelihood of Inattention symptoms even when early disrupted care arrangements are followed by stable relationships with adoptive parents.

Specifically, in both FC and PI groups, the longer the duration prior to stable placement in their adoptive families, the more inattention symptoms they exhibited. However, this was only true for children with poorer error monitoring, as indexed by the ERN. This is in line with previous studies that have indicated that despite well established associations between early life adversity and symptoms of psychopathology, some children show resilience. More specifically, child ERN - a neural indicator of response monitoring (Hall et al. 2007, Olvet and Hajcak 2008) – appears to buffer deprivation-related risk, most notably for attention regulatory and externalizing problems. However, these buffering effects have been previously studied only in non-adopted samples, which have typically included children older than those assessed here, and whom were also more likely to have histories of greater post-placement residential instability (McDermott et al., 2013; Troller Renfree et al., 2016). Thus, the current study is the first to investigate whether similar patterns of risk and resilience occur in younger children who were adopted into stable placements. Future studies may wish to directly assess the effects of residential instability comparing between children who experienced varying levels of instable/stable residential placements.

Our finding of error monitoring as a significant protective factor is in line with the diathesis-stress theory, suggesting that children may display dispositional capacities of regulation that compensate for disadvantageous caregiving experiences (Slagt et al. 2016). More specifically, the above result held both for PI and FC children. We are aware of one other study that investigated interactive associations between duration of institutionalized care and ERN (Troller-Renfree et al., 2016). Using a combined measure of externalizing and ADHD symptoms, Troller-Renfree et al. (2016), showed that longer duration of institutional-care, was associated with increased symptomology, however only for children with small ERNs. Interestingly, contrary to the findings of our study, separate analyses of each of the Externalizing and ADHD subscales revealed significant moderation effects of the ERN for externalizing behavioral problems as well as marginal moderation effects for impulsivity; however, the inattention subscale did not appear to be moderated by the ERN. These results were from the Bucharest Early Intervention Study (Zeanah et al. 2003), a study that recruited Romanian children who were institutionalized, the majority from close to birth, and were randomized to either study-supported foster care or care as usual when the children averaged two years of age. Troller-Renfree et al (2016) followed them up at early adolescence (12 years of age), a timepoint at which 34% of the care-as-usual children still resided under institutionalized care. While the present study revealed significant moderation effects for inattention and not for impulsivity, findings of both studies are comparable in that they both demonstrate the detrimental impact of being without a permanent family on the one hand, and the protective role of children's error monitoring on the other hand. Importantly, the present findings suggest that these detrimental effects may be evident much earlier than early adolescence and in fact may occurr during early development.

Future research is necessary to shed light on the discrepant findings of risk for inattention versus impulsivity. Discrepancies may be explained by both the extent of adversity and the setting in which children resided at the time of data collection (adoptive families in the present study versus 34% of the Bucharest sample which still resided in institutionalized care), as well as the age at which outcomes were assessed (5 years of age in the present study versus early adolescence in the Bucharest sample). Prospective longitudinal followup of the current sample would allow to assess whether risk for impulsivity may become more evident as the children grow older.

Moreover, the unique charactistics of the present sample allowed us to reveal the important finding that regardless of *type* of early caregiving setting (i.e. group), for children with deficits in error monitoring, duration of pre-adoptive out of home placement was a significant risk factor for symptoms of inattention - despite having had experienced at least 3 years of stable relatively enriched post-adoptive care. These findings point toward the perisitent detrimental effects that early adversity may have on the developing brain and clearly point toward the need to place children in permanent families as soon as possible.

Noteworthy, the present findings should be viewed in light of a few limitations. Assessment of ADHD symptoms relied soley on parent report ratings. While such measures have been found to be adequately reliable (Essex et al. 2002), accurate diagnosis of symtoms at the young age of 5 years tends to be particularly challenging. In addition, adoptive parents may over-diagnose, in part due to concerns and conscientiousnsess, thus possibly biasing the results. While the moderating role of the ERN would not be effected by such biases, the Group effects demonstrated in the present study warrant further replication. Future research may benefit from relying on multiple-informants as well as clinical observations in the assessment of ADHD symptomology. In addition, the present study demonstrated that children display persistent risk for attentional problems despite having had experienced up to 3-years of relatively enriched and supportive caregiving in post-adoptive care. Indeed, various studies have shown that attention problems tend to persist, even after years of stable enriched adoptive care (e.g., as measured at 18 years old; Gunnar & Van Dulmen, 2007; Hawk & McCall, 2011). Prospective longitudinal followup of the current sample is necessary to investigate whether attentional problems continue to persist or whether extended duration in family care may eventually yield modulation of attentional problems over time. Prospective followup would also allow to identify contextual factors which might foster such modulation. Previous reports on observed parenting quality in this same sample (Lawler, Koss & Gunnar, 2017), found that while there were no significant differences in parenting quality between adoptive and nonadoptive parents, for post-institutionalized youth, higher quality of parental structure and limit-setting soon after adoption predicted reduced child regulation difficulties 8 months later. These findings suggest that variability in post placement parenting behaviors may impact the associations examined in the present manuscript. Thus, in addition to the moderating role of the ERN, future research may wish to examine the moderating role of post adoptive parenting on the association between duration and child outcome.

Practice and Policy Implications

Literature suggests that even under the condition of caring institutional staff, institutional settings entail an inherent developmental risk due to characteristics of depersonalization (e.g. lack of personal possessions, care relationships, or symbols of individuality), strict routines, group treatment, and isolation from wider society (e.g., Berens & Nelson, 2015). Given these inherent risks recent policy statements call for family placement of all children, and progressive replacement of institutional care with quality alternative care (Berens & Nelson, 2015; The United Nations, 2019). The present findings support this notion, showing the benefits of placing institutionalized children into stable homes as early as feasible for optimizing their long-term developmental outcome.

Importantly though, the recommendation to place children in homes rather than institutions, holds only if the adoptive home is indeed one that provides nurturing care. Finding and placing children in stable and nurturing adoptive homes entails various challenges. Abundant research has documented great individual differences in quality of family-based care (Bornstein, 2019), and adoptive families often experience even greater challenges due to amplified caregiving needs which are specific to the context of adoption (e.g. helping the child cope with adoption-related loss, experience of early trauma and more; Brodzinsky & Pinderhughes, 2005). Taken together, the recommendation to place children in homes rather than institutions, has to be considered in light of the several challenges and barriers that may compromise the quality of post-adoptive care. These challenges have critical implications on policy, as noted in recent policy statements, calling for robust screening of adoptive families, adequate training and support for caregivers, as well as mechanisms which ensure the ongoing monitoring of the quality of adoptive caregiving (The United Nations, 2019).

Furthermore, despite the indisputable benefit of early placement into stable homes, there is often a lack of available resources thus making it pertinent to identify which children might be particularly vernerable and what mechanisms might be targeted to foster their resilience. As such, the present study adds to previous literature in that it reveals that for some children, home care in itself, may not override the deleterious effect of institutional care, and later placement into home care places these "at-risk" children at even greater risk. The study points toward a potential protective mechanism which may be targeted in preventive interventions with these "at-risk" children and suggests that error monitoring, and perhaps more generally, cognitive control skills may protect against the negative impact of adversity early in life. There are increasing attempts to train cognitive control skills in young children, and although not all cognitive interventions have been found to be effective, particularly with youg children, some interventions did evidence success (Diamond and Ling 2016). To the extent that these skills are malleable early in life, it would seem that evidence-based interventions targeting those skills would be important to children growing up under conditions similar to those experienced by the PI and FC children in the present study. Interestingly, a study that targeted self-regulation skills in high risk preschoolers using a randomized design showed that children receiving the intervention exhibited a feedback negativity response to errors on a flanker task, while those who did not receive the intervention did not (McDermott et al. 2018). Thus, identifying at risk children whose cognitive control skills are weak and further developing intervention strategies to effectively enhance them might be an important direction for practice and policy.

Acknowledgments

This work was supported by the Early Experience, Stress and Neurodevelopment Center (HD P50 MH78105) with Megan R. Gunnar as Director and Nathan Fox as PI of the Electrophysiological Core, by R01 MH080905 to Gunnar, and by the Center for Neurobehavioral Development, University of Minnesota. The authors would like to thank the members of the Minnesota International Adoption Project team for their efforts in collecting these data including Bao Moua and Alyssa Miller, as well as to Connie Lamm for her early help with the ERP task implementation. The authors are grateful to the parents and children for their participation in this project.

References

Allison PD (2003). Missing data techniques for structural equation modeling. Journal of abnormal psychology, 112(4), 545–557. [PubMed: 14674868]

Astley SJ, & Clarren SK (2000). Diagnosing the full spectrum of fetal alcohol-exposed individuals: introducing the 4-digit diagnostic code. Alcohol and alcoholism, 35(4), 400–410. [PubMed: 10906009]

Berens Nelson, 2015 The science of early adversity: is there a role for large institutions in the care of vulnerable children? Lancet, 386, 388–398. [PubMed: 25638660]

Bornstein MH (Ed.). (2019). Handbook of parenting: Children and parenting (3rd ed.). New York: Routledge.

Boyce WT, Essex MJ, Woodward HR, Measelle JR, Ablow JC, Kupfer DJ, et al. (2002). The confluence of mental, physical, social, and academic difficulties in middle childhood. I: Exploring the "headwaters" of early life morbidities. Journal of the American Academy of Child & Adolescent Psychiatry, 41(5), 580–587. [PubMed: 12014791]

Brodzinsky DM, & Pinderhughes E (2005). Parenting and child development in adoptive families. Handbook of parenting, 1, 279–311.

Bruce J, McDermott JM, Fisher PA, & Fox NA (2009). Using behavioral and electrophysiological measures to assess the effects of a preventive intervention: A preliminary study with preschool-aged foster children. Prevention Science, 10(2), 129–140. [PubMed: 19030992]

Colvert E, Rutter M, Beckett C, Castle J, Groothues C, Hawkins A, et al. (2008). Emotional difficulties in early adolescence following severe early deprivation: Findings from the English and Romanian adoptees study. Development and psychopathology, 20(2), 547–567. [PubMed: 18423094]

Diamond A, & Ling DS (2016). Conclusions about interventions, programs, and approaches for improving executive functions that appear justified and those that, despite much hype, do not. Developmental cognitive neuroscience, 18, 34–48. [PubMed: 26749076]

Essex MJ, Boyce WT, Goldstein LH, Armstrong JM, Kraemer HC, Kupfer DJ, et al. (2002). The confluence of mental, physical, social, and academic difficulties in middle childhood. II: Developing the MacArthur Health and Behavior Questionnaire. Journal of the American Academy of Child & Adolescent Psychiatry, 41(5), 588–603. [PubMed: 12014792]

Falkenstein M, Hoormann J, Christ S, & Hohnsbein J (2000). ERP components on reaction errors and their functional significance: a tutorial. Biological psychology, 51(2–3), 87–107. [PubMed: 10686361]

Gehring WJ, Goss B, Coles MG, Meyer DE, & Donchin E (1993). A neural system for error detection and compensation. Psychological science, 4(6), 385–390.

Gunnar MR, & Van Dulmen MH (2007). Behavior problems in postinstitutionalized internationally adopted children. Development and psychopathology, 19(1), 129–148. [PubMed: 17241487]

Hajcak G (2012). What we've learned from mistakes: Insights from error-related brain activity. Current Directions in Psychological Science, 21(2), 101–106.

Hall JR, Bernat EM, & Patrick CJ (2007). Externalizing psychopathology and the error-related negativity. Psychological science, 18(4), 326–333. [PubMed: 17470258]

Hawk BN, & McCall RB (2011). Specific extreme behaviors of postinstitutionalized Russian adoptees. Developmental psychology, 47(3), 732–738. [PubMed: 21219071]

Hayes AF (2017). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. New York: Guilford Publications.

Hayes AF (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. Communication monographs, 76(4), 408–420.

Hostinar CE, Stellern SA, Schaefer C, Carlson SM, & Gunnar MR (2012). Associations between early life adversity and executive function in children adopted internationally from orphanages. Proceedings of the National Academy of Sciences of the United States of America, 109 Suppl 2, 17208–17212. [PubMed: 23047689]

Johnstone SJ, Barry RJ, & Clarke AR (2013). Ten years on: a follow-up review of ERP research in attention-deficit/hyperactivity disorder. Clinical Neurophysiology, 124(4), 644–657. [PubMed: 23063669]

Kreppner JM, O'Connor TG, Rutter M, & English and Romanian Adoptees Study Team. (2001). Can inattention/overactivity be an institutional deprivation syndrome?. Journal of abnormal child psychology, 29(6), 513–528. [PubMed: 11761285]

Lamm C, White LK, McDermott JM, & Fox NA (2012). Neural activation underlying cognitive control in the context of neutral and affectively charged pictures in children. Brain and cognition, 79(3), 181–187. [PubMed: 22542842]

Lawler JM, Koss KJ, & Gunnar MR (2017). Bidirectional effects of parenting and child behavior in internationally adopting families. Journal of Family Psychology, (5); 563–573. [PubMed: 28263623]

Loman MM, Johnson AE, Westerlund A, Pollak SD, Nelson CA, & Gunnar MR (2013). The effect of early deprivation on executive attention in middle childhood. Journal of Child Psychology and Psychiatry, 54(1), 37–45. [PubMed: 22924462]

McDermott JM, Westerlund A, Zeanah CH, Nelson CA, & Fox NA (2012). Early adversity and neural correlates of executive function: Implications for academic adjustment. Developmental Cognitive Neuroscience, 2, S59–S66. [PubMed: 22682911]

McDermott JM, Pears KC, Bruce J, Kim HK, Roos L, Yoerger KL, et al. (2018). Improving kindergarten readiness in children with developmental disabilities: Changes in neural correlates of response monitoring. Applied Neuropsychology: Child, 7(3), 187–199. [PubMed: 28631968]

McDermott JM, Troller Renfree SV, Vanderwert R, Nelson CA, Zeanah CH, & Fox N (2013). Psychosocial deprivation, executive functions, and the emergence of socioemotional behavior problems. Frontiers in human neuroscience, 7, 167–178. [PubMed: 23675333]

Olvet DM, & Hajcak G (2009). The stability of error- related brain activity with increasing trials. Psychophysiology, 46(5), 957–961. [PubMed: 19558398]

Olvet DM, & Hajcak G (2008). The error-related negativity (ERN) and psychopathology: toward an endophenotype. Clinical psychology review, 28(8), 1343–1354. [PubMed: 18694617]

Pasion R, & Barbosa F (2019). ERN as a transdiagnostic marker of the internalizing-externalizing spectrum: A dissociable meta-analytic effect. Neuroscience & Biobehavioral Reviews. doi: 10.1016/j.neubiorev.2019.06.013

Pollak SD, Nelson CA, Schlaak MF, Roeber BJ, Wewerka SS, Wiik KL, et al. (2010). Neurodevelopmental effects of early deprivation in postinstitutionalized children. Child development, 81(1), 224–236. [PubMed: 20331664]

Pontifex MB, Scudder MR, Brown ML, O'Leary KC, Wu C, Themanson JR, et al. (2010). On the number of trials necessary for stabilization of error- related brain activity across the life span. Psychophysiology, 47(4), 767–773. [PubMed: 20230502]

Rutter M, Sonuga-Barke EJ, Beckett C, Castle J, Kreppner J, Kumsta R, et al. (2010). Deprivation-specific psychological patterns: Effects of institutional deprivation. Monographs of the Society for Research in Child Development, 1–253. [PubMed: 20500631]

Rutter M, Kreppner J, & O'Connor T (2001). Specificity and heterogeneity in children's responses to profound institutional privation. The British Journal of Psychiatry, 179(2), 97–103. [PubMed: 11483469]

Slagt M, Dubas JS, Deković M, & van Aken MA (2016). Differences in sensitivity to parenting depending on child temperament: A meta-analysis. Psychological bulletin, 142(10), 1068–1110. [PubMed: 27513919]

Sonuga-Barke EJ, Kennedy M, Kumsta R, Knights N, Golm D, Rutter M, et al. (2017). Child-to-adult neurodevelopmental and mental health trajectories after early life deprivation: the young adult follow-up of the longitudinal English and Romanian Adoptees study. The Lancet, 389(10078), 1539–1548.

Stevens SE, Sonuga-Barke EJ, Kreppner JM, Beckett C, Castle J, Colvert E, et al. (2008). Inattention/overactivity following early severe institutional deprivation: presentation and associations in early adolescence. Journal of abnormal child psychology, 36(3), 385–398. [PubMed: 17965931]

The United Nations General Assembly resolution 74/395, Promotion and protection of the rights of children, A/74/395 (27 November 2019), available from undocs.org/A/74/395.

Troller Renfree S, Nelson CA, Zeanah CH, & Fox NA (2016). Deficits in error monitoring are associated with externalizing but not internalizing behaviors among children with a history of institutionalization. Journal of Child Psychology and Psychiatry, 57(10), 1145–1153. [PubMed: 27569003]

U.S. Department of State. (2018). Annual Report on Intercountry Adoption. https://travel.state.gov/content/dam/NEWadoptionassets/pdfs/Tab%201%20Annual%20Report%20on%20Intercountry%20Adoptions.pdf.

Wade M, Zeanah CH, Fox NA, & Nelson CA (2019). Global deficits in executive functioning are transdiagnostic mediators between severe childhood neglect and psychopathology in adolescence. Psychological medicine, 1–8.

Zeanah CH, Nelson CA, Fox NA, Smyke AT, Marshall P, Parker SW, et al. (2003). Designing research to study the effects of institutionalization on brain and behavioral development: The Bucharest Early Intervention Project. Development and psychopathology, 15(4), 885–907. [PubMed: 14984131]

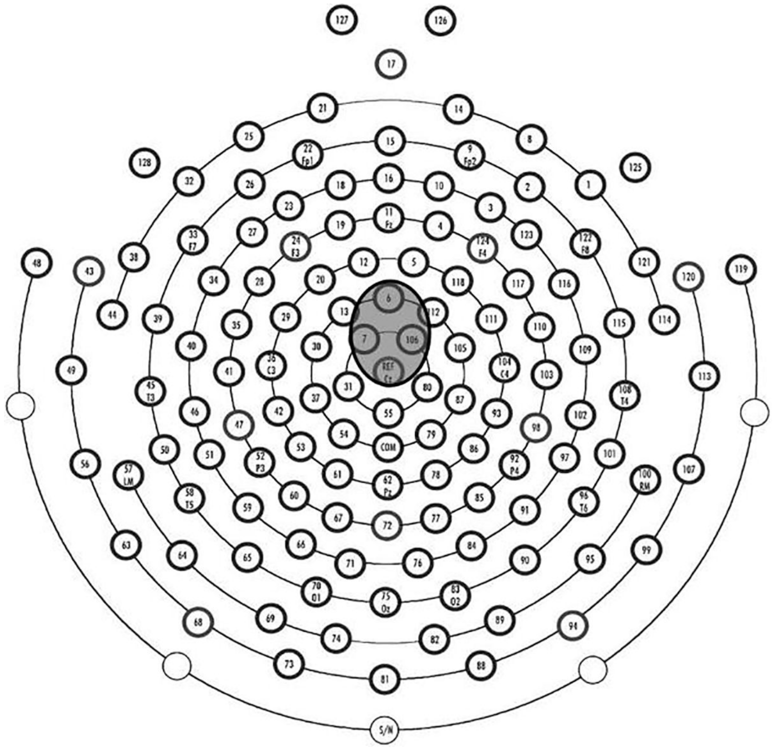

Fig 1.

Sensor Net Layout. ERN peak amplitude was averaged across the four indicated mediofrontal electrodes (Cz, FCz, 7, 106) where ERN activation reached maximal negativity.

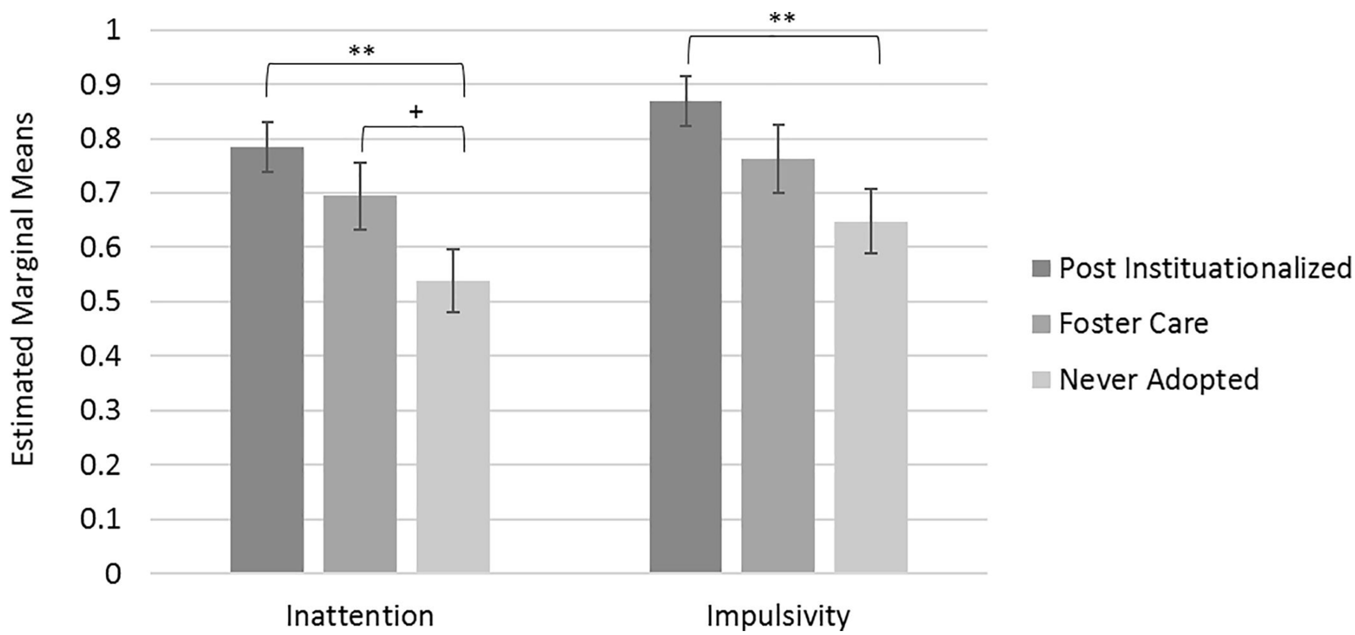

Fig 2.

Group differences in Inattention and Impulsivity

** $p < 0.01$; $^{+}$ $p < 0.09$

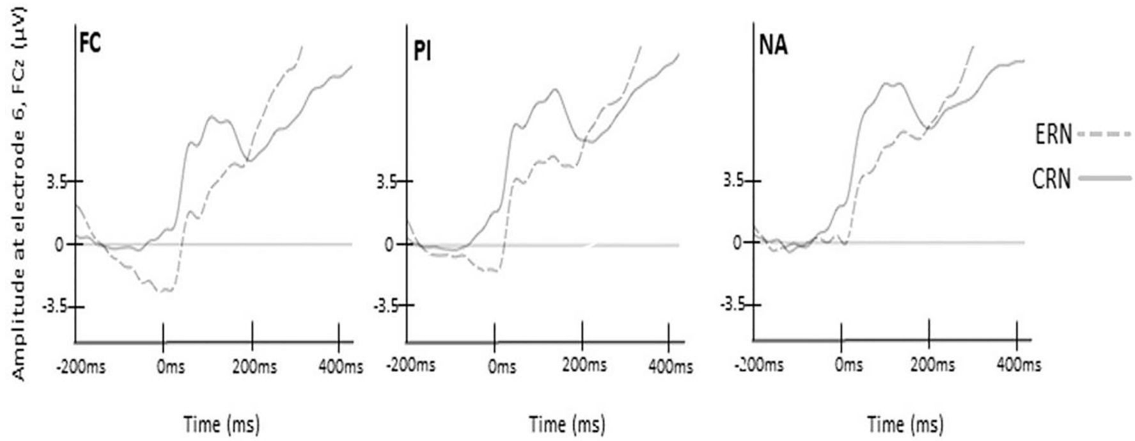

Fig 3.
ERN and CRN waveforms by Group

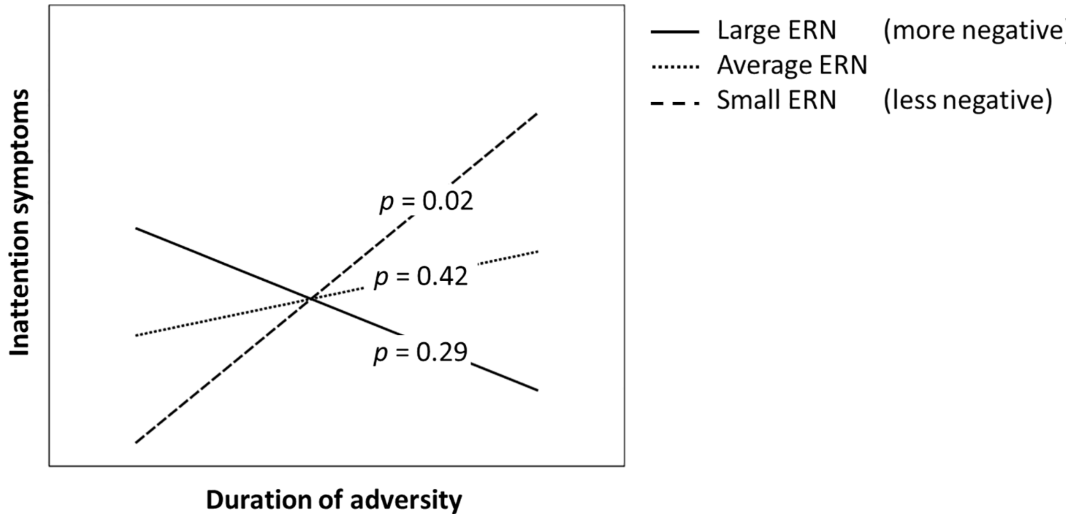

Fig 4.
Moderating effect of ERN on the association between duration of out-of-home placement and inattention symptoms

Table 1.

Participant Demographics by Group.

	PI	**FC**	**NA**
Total *N*	80	44	48
Child Sex (*N* Female)	45	16	23
Age in months *M (SD)*	61.54 (1.70)	63.63 (2.50)	61.91 (1.89)
Child Race (*N*)			
African/Black	28	0	0
American Indian/Alaska Native	4	10	0
Asian	32	32	2
White	11	0	42
Multiracial	2	0	4
Unknown	3	2	0
Child Ethnicity (*N*)			
Hispanic/Latino	6	12	2
Region of Origin (*N*)			
Africa	23	0	0
Latin America/Caribbean	12	12	0
Russia/Eastern Europe	21	0	0
Southeast Asia	24	32	0
United States	0	0	48
Primary Caregiver (*N* Female)	74	40	47
Marital Status (*N* Married)	69	42	46
Primary Caregiver Education (Median)	Bachelor’s Degree	Bachelor’s Degree	Bachelor’s Degree
Secondary Caregiver Education (Median)	Bachelor’s Degree	Bachelor’s Degree	Bachelor’s Degree
Median Household Income in thousands	$100–$125	$100–$125	$75–$100

Note. There were no differences in household income by group [$\chi^2(16)=15.91$, $p=.459$.

Table 2.

Correlation Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
All participants														
1. Externalizing Symptoms	---													
2. ADHD Symptoms	.51***	---												
3. Internalizing Symptoms	.49***	.32***	---											
4. ERN	.07	−.08	.06	---										
5. CRN	−.01	−.20	.05	.74***	---									
6. Go Accuracy	−.03	−.14	−.02	−.12	.09	---								
7. NoGo Accuracy	−.06	−.13	−.03	.17	.37***	−.05	---							
8. Go Correct Reaction Time	−.01	−.03	.05	.30**	.31**	−.47***	.53***	---						
9. NoGo Incorrect Reaction Time	−.06	−.01	.03	.34***	.29**	−.49***	.26**	.81***	---					
10. Age of child at data collection	−.02	.02	.08	−.25**	−.19*	.13	−.07	.04	.05	---				
11. Duration of out-of-home placement	−.08	.15	.00	.18	.05	−.14	−.08	−.03	.08	−.15	---			
12. Artifact-free trials in ERP waveforms locked to erred No-Go responses	.04	.21**	.01	−.03	.00	.14	−.52***	−.33***	−.24**	.02	−.01	---		
13. Artifact-free trials in ERP waveforms locked to correct Go responses	.00	.09	−.05	.11	.35***	.29***	−.08	−.13	−.19*	.03	−.14	.71***	---	
14. Number of pre-adoptive care settings	.09	.00	.18	.20	.20	−.09	.00	.11	.10	−.13	−.26**	.10	.16	---

Note.

* $p<.05$,

** $p<.01$,

*** $p<.001$.

Due to a high correlation between the amount of artifact-free trials in ERP waveforms locked to correct Go and locked to erred No-Go responses, these variables were averaged to a single score for use in analyses that included both variables as covariate

Table 3.

Group and Sex Differences among Study Variables

3 Group Comparisons	PI	FC	NA			
	M (SD)	*M (SD)*	*M (SD)*	**df**	***F***	**Pairwise Comparisons**
Externalizing Symptoms	0.31 (0.22)	0.30 (0.19)	0.23 (0.18)	2, 165	2.01 +	PI>NA +
ADHD Symptoms	0.82 (0.44)	0.75 (0.33)	0.60 (0.32)	2, 167	4.97 **	PI>NA **
Internalizing Symptoms	0.28 (0.17)	0.30 (0.18)	0.25 (0.20)	2,168	0.99	ns
ERN	0.22 (4.05)	−1.27 (3.85)	0.89 (3.92)	2, 101	2.14	ns
CRN	1.89 (2.98)	0.87 (3.00)	2.67 (3.45)	2, 101	2.27	ns
Go Accuracy	0.79 (0.14)	0.86 (0.92)	0.85 (0.11)	2, 160	6.89	FC>PI ** ; NA>PI **
NoGo Accuracy	0.55 (0.17)	0.57 (0.18)	0.53 (0.17)	2, 160	0.63	ns
Go Reaction Time	657.80 (116.01)	647.26 (81.89)	648.93 (93.10)	2, 159	0.18	ns
NoGo Incorrect Reaction Time	579.79 (142.44)	542.29 (66.49)	551.51 (88.24)	2, 159	1.79	ns
Age of child at data collection	61.55 (1.69)	63.63 (2.50)	61.91 (1.89)	2, 169	16.29 ***	FC>NA,PI ***
Clean incorrect no-go trials	14.77 (10.00)	13.67 (13.67)	13.80 (8.94)	2, 158	0.23	ns
Clean correct go trials	68.59 (44.54)	69.74 (45.22)	67.58 (44.59)	2,158	0.03	ns
				df	***t***	**T-tests**
Duration of out-of-home placement in months	19.09 (7.75)	8.84 (1.75)	---	86.54	10.97	PI>FC ***
Number of pre-adoptive care settings	2.56 (0.89)	2.59 (0.79)	---	120	−0.17	ns

Sex Comparisons	Female	Male			
	M (SD)	*M (SD)*	**df**	***t***	**T-tests**
Externalizing Symptoms	0.27 (0.22)	0.29 (0.19)	166	−0.74	ns
ADHD Symptoms	0.68 (0.38)	0.79 (0.39)	168	−1.98	M>F *
Internalizing Symptoms	0.25 (0.15)	0.31 (0.21)	158	−2.19	M>F *
ERN	0.44 (3.80)	−0.43 (4.20)	102	1.11	ns
CRN	2.28 (3.05)	1.38 (3.21)	102	1.47	ns
Go Accuracy	0.82 (0.13)	0.83 (0.12)	161	−0.76	ns
NoGo Accuracy	0.60 (0.15)	0.51 (0.17)	161	3.38	F>M **

Go Reaction Time	674.46 (94.10)	633.09 (103.71)	160	2.65	F>M**
NoGo Incorrect Reaction Time	575.99 (120.73)	549.28 (104.22)	160	1.51	ns
Age of child at data collection	61.86 (1.81)	62.49 (2.40)	170	−1.92	M>F+
Artifact-free trials in ERP waveforms locked to erred No-Go responses	13.76 (9.10)	14.64 (10.12)	157	−0.58	ns
Artifact-free trials in ERP waveforms locked to correct Go responses	70.96 (43.04)	66.30 (45.97)	157	0.66	ns
Duration of out-of-home placement in months	15.97 (8.10)	14.78 (7.89)	116	0.81	ns
Number of pre-adoptive care settings	2.42 (0.86)	2.71 (0.83)	120	−1.90	ns

Note.

+ $p<0.07$,

* $p<.05$,

** $p<.01$,

*** $p<.001$.