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Impact of early institutionalization on attention mechanisms underlying the inhibition of a planned action

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ABSTRACT

Institutional rearing is associated with deficits in executive functions, such as inhibitory control, and may contribute to later externalizing behavior problems. In the current study, we explored the impact of institutional rearing on attention in the context of inhibiting a planned action. As part of the Bucharest Early Intervention Project (BEIP), children were randomized to either remain in the institutions in which they lived (Care as Usual Group) or be placed into foster family homes (Foster Care Group). We also recruited age and gender matched never-institutionalized (NIG) children from the Bucharest community. We examined differences in behavioral and Event Related Potentials (ERPs) during a go-no-go task when children were 12 years old. Results revealed that the ever-institutionalized group (CAUG and FCG combined) showed slower reaction times, worse performance accuracy, larger P2 activation, and smaller (less negative) N2 activation than the NIG group. Results of a moderation analysis revealed that children who spent more time in institutions and had small N2s showed more externalizing symptoms. These results have implications for the design of treatment approaches for previously institutionalized children with externalizing behavior problems.

1. Introduction

A large number of children reared in institutions exhibit signs of externalizing disorders (e.g., Humphreys et al., 2015; Merz and McCall, 2010; Stevens et al., 2008; Wiik et al., 2011; Zeanah et al., 2009). However, not all institutionally reared children go on to develop externalizing behavior problems (e.g., Humphreys et al., 2015; Merz and McCall, 2010; Wiik et al., 2011; also see review by Troller-Renfree et al., 2017). For example, Merz and McCall (2010) found that roughly between 20% and 35% of previously institutionalized children, primarily from Russia and Romania, compared with 10% of non-deprived adopted children in the US, showed externalizing behavior problems. Similarly, Wiik et al. (2011) found that roughly 16% of previously institutionalized children adopted internationally, compared to 4% for non-adopted children, showed externalizing behavior problems. Additionally, the levels of externalizing behavior problems outlined by Wiik et al. (2011), as well as by Merz and McCall (2010) for previously institutionalized children is considerably higher than the 7.1% mean level of externalizing problems for non-previously institutionalized children (across 9 countries) found by Crijnen et al. (1997). Therefore, investigators have started to examine which factors might moderate the association between early institutional rearing and externalizing behavior (e.g., McDermott et al., 2013; Troller-Renfree et al., 2016). For example, Troller-Renfree et al. (2016) found that brain activation associated with error processing moderated the association between amount of time spent in the institution and externalizing behaviors.

Additionally, several studies have shown that early institutional rearing contributes to deficits in executive functions (Bos et al., 2009; Bruce et al., 2009; Merz and McCall, 2010; Pollak et al., 2010; Tibu et al., 2016), including inhibitory control (e.g., McDermott et al., 2012; Pollak et al., 2010), i.e., the ability to inhibit a planned action (Schachar et al., 1995), and that deficits in inhibitory control are associated with externalizing behavior problems (Huijbregts et al., 2008; Schachar et al., 1999, 1995; Tibu et al., 2016). Thus, the current study examined if deficits in the ability to inhibit a planned action and perturbations in the neural correlates that contribute to inhibitory control might moderate the association between institutional rearing and externalizing symptoms.

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To efficiently inhibit a planned action, several attention mechanisms need to be applied (as discussed in Aron, 2007; Cisek, 2007; Ridderinkhof et al., 2004). To examine these attentional mechanisms, in the current study we measured three components of the event-related potential (ERP)—the P2, N2, and P3—in the context of a task that requires inhibition of a planned action (go-no-go task). ERPs were used to decompose the neural chronometry underlying the inhibition of a planned action because of their excellent temporal specificity (Kappenman and Luck, 2012; Hillyard and Anllo-Vento, 1998).

Previous studies have associated P2 activation, a mediofrontal ERP found in adults roughly 200–300 ms after stimulus onset, with attentional orienting (Kanske et al., 2011; Maeno et al., 2004; Van Voorhis and Hillyard, 1977). Furthermore, Loman and colleagues found that in the context of a go-no-go task previously institutionalized children had larger P2s for no-go trials compared to go trials but that this effect was not evident for non-institutionalized children (Loman et al., 2013). Thus, we predicted that P2 activation would be enhanced in previously institutionalized children and moderate the association between institutional rearing and externalizing symptoms; specifically, that institutionalized children with large P2s would show the most externalizing symptoms.

Studies have associated N2 activation—a mediofrontal ERP found in adults roughly 250–350 ms after stimulus onset—with various aspects of cognitive control, including response monitoring or response conflict (Bartholow et al., 2005; Dimoska et al., 2006; Donkers and Van Boxtel, 2004; Nieuwenhuis, Yeung, van den Wildenberg, & Ridderinkhof, 2003; Van Veen and Carter, 2002). Loman et al. (2013) also examined the impact of institutionalization on N2 amplitudes and found that N2s were smaller (less negative) for institutionalized children compared to non-institutionalized children. Additionally, Troller-Renfree et al. (2016), using the same sample, found that another mediofrontal ERP also associated with response processing (the ERN) moderated the association between amount of time-spent-in-the-institution and externalizing behavior problems. Therefore, we predicted that institutionally reared children with smaller N2s would show the most externalizing symptoms but that this would not be the case for institutionally reared children with large N2s, i.e., that the N2 would moderate the association between time-spent-in-the-institution and externalizing symptoms.

Lastly, the P3 —an ERP component that peaks in adults roughly at 300 ms after stimulus onset—has been associated with context updating in working memory (Donchin, 1981; for a review see Polich, 2012). McDermott et al. (2012) found deficient P3 activation for previously institutionalized and foster care children compared to never institutionalized children in the context of a go-no-go task. Thus, we predicted that children who were institutionally reared would exhibit smaller P3 amplitudes and that children with small P3s would show the most externalizing symptoms.

The goals of the current study are to determine: 1) if removal from an institution and subsequent placement in foster care early in life impacts neural activation underlying one's ability to inhibit planned actions, at age 12 years, and 2) if patterns of neural activation (P2, N2, and P3) underlying the ability to inhibit a planned action moderates the association between amount of time-in-institution and externalizing symptoms. These questions were explored in the context of the Bucharest Early Intervention Project (BEIP), the first randomized control trial of a foster care intervention for institutionalized children (for details see Zeanah et al., 2003).

2. Method

2.1. Participants

Participants were part of the Bucharest Early Intervention Project (BEIP; Zeanah et al., 2003), a randomized controlled trial comparing the effects of foster care as an alternative to institutional care for young children abandoned at birth and placed in institutions. For a detailed breakdown of the history, design, and implementation of this study, please see Zeanah et al. (2003). This study assessed 136 children between the ages of 6 and 31 months who were institutionalized in Bucharest, Romania, and who at that time had spent at least half of their lives living in an institution. After initial assessment of all children, half of the institutionalized sample (n = 68; 33 boys and 35 girls) was randomly assigned to continued institutional care (care as usual, CAU) and the other half of the sample (n = 68, 34 boys and 34 girls) was assigned to foster care (FC; see Zeanah et al., 2003, for a full description of the sample). Both groups (CAUG and FCG) were followed systematically through 12 (mean = 12.63, SD = 0.55) years of age. Additionally, a separate never institutionalized group (NIG) of age- and gender-matched children (n = 52, 23 boys and 29 girls; mean age = 12.68, SD = 0.39) from the Bucharest area were recruited as a comparison group. The current study presents ERP and clinical symptom data collected at 12 years of age and includes 144 participants (CAUG: male 26, female 21; FCG: male 26, female 23; NIG: male 22, female 26). Participants were excluded from this study for a number of reasons, including that the child did not participate in the 12-year visit (11 CAUG, 12 FCG), go-no-go data was missing (8 CAUG, 6 FCG, 4 NIG), and because ERPs were comprised of too few artifact free trials (2 CAUG, 1 FCG). Missing data was compared to analyzed data for differences in gender, $\chi^2(1, N = 188) = 3.05$, $p = 0.08$, age, $t(156) = -0.18$, $p = 0.86$, ethnicity, $\chi^2(3, N = 188) = 4.73$, $p = 0.19$, group status, $\chi^2(2, N = 188) = 10.06$, $p = 0.007$, and severity of externalizing symptoms, $t(157) = -0.58$, $p = 0.56$. For the significant group status analysis, fewer NIG children had missing data for the 12-year visit than CAUG and FCG children.

2.2. Measures

2.2.1. Diagnostic Interview Schedule for Children, 4th Edition; DSM-IV (DISC; Shaffer et al., 2000)

The DISC is a structured psychiatric interview assessment tool that is both reliable and valid for children 6 years and older. The DISC probes current symptom levels, duration or persistence, age of onset, and functional impairment. For the NIG and FCG groups, the parent report was obtained from the mother if available, otherwise fathers provided the report. For the CAUG children, an institutional caregiver who worked with the child regularly and knew them well reported on the child's behavior. For more information on how the DISC was administered within the BEIP study, please see Humphreys et al. (2015). For the current study, only the Attention-Deficit/Hyperactivity Disorder (ADHD), Oppositional Defiant Disorder (ODD), and Conduct Disorder (CD) modules were used. The Mean internal consistency values for our study was 0.77.

2.2.2. MacArthur Health and Behavior Questionnaire (HBQ; Luby et al., 2002)

The HBQ parent report is a reliable and valid measure of the physical and mental health of young children. This measure yields dimensional ratings of current functioning in the domains of 1) emotional and behavioral symptomatology, 2) physical health, 3) social adaption, and 4) school adaptation, to comprise 18 subscales covering a number of behavior problems, including ADHD and externalizing symptoms. The Mean internal consistency values for our study was 0.88. For the current study, we used the same reporter for the CAUG, FCG, and NIG children as described above for the DISC.

2.2.3. Go-no-go task (McDermott et al., 2012)

The current task was a modified version of the traditional letter go-no-go task (Conners et al., 2000) and was presented on a 17-in computer monitor using E-Prime software (Psychological Software Tools, Pittsburgh, PA; Schneider et al., 2002). The timing and appearance of the traditional go-no-go task was altered slightly to make it appropriate