NEUROIMAGING AND BEHAVIORAL DYSFUNCTIONS IN INSTITUTIONALIZED CHILDREN

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ABSTRACT

Most of the undesired behaviors of institutionalized children do not stem from the labels that those children receive pretty often as being "rude" or "malevolent", but from the brain dysfunctions caused by severe social and environmental deprivation, increasing the risk for psychopathology. In this article we will try to emphasize on the fact that these children's developmental trajectory is considerably improved if they are integrated in families before the age of 2. The investment in families is more beneficial for their neuropsychomotor development than keeping those children in institutions. Children with frontal electroencephalography asymmetry get to experience major effects in response to negative emotional stimuli in adulthood.

Keywords: institutional children, brain, behavior, EEG, adoption.

INTRODUCTION

Extremes of early experience provide opportunities to explore the origins of psychopathology. In fact, the association between adverse early experiences and later psychiatric morbidity seems increasingly clear [1]. Certain features characterize most institutional care for young children: regimented daily schedules, high ratios of children to caregivers, non-individualized care, lack of psychological involvement of caregivers, and rotating caregiver shifts, which all contribute to an adverse caregiving and social environment [2].

Not surprisingly, young children adopted out of institutions characterized by social and material deprivation have been shown to be at risk for a variety of psychiatric sequelae, such as attachment disorders [3], attention deficit hyperactivity disorder (ADHD) [4], and posttraumatic stress disorder [5].

Young children who are institutionalized usually have a variety of genetic and prenatal risk factors that precede their placement. Despite this, many children adopted from institutions seem not to have serious psychopathology, at least when assessed several years following adoption [6], suggesting that enhanced caregiving environments following adoption may reduce the likelihood of psychopathology. This is not surprising given the vast amount of developmental research suggesting that outcomes at particular points in their
development are the result of ongoing interactions between a child’s characteristics (including genetic endowment and early experiences) and the environment characteristics. All current research attempts to examine whether a dramatic change in caregiving environments, randomly allocated to children with significant histories of adversity, can change children’s developmental trajectories from psychopathology toward more adaptive behaviors, and it attempts to determine which characteristics in which individuals are more or less amenable to intervention.

UNICEF estimates that there are at least 8 million children worldwide in the social protection system. In Romania there are 58,702 institutionalized children and the data obtained from the Romanian Office for Adoptions are worrisome: 12,754 children are raised in family type houses and apartments, 18,815 are in foster care, 18,160 are in simple placement to relatives or to other families, 7,000 children were declared adoptable but only 2,000 of them were entrusted to adoption families in the last three years. 10% of institutionalized children were hospitalized over the last year in psychiatric wards and the average hospitalization period was of approximately 13 days. The large number of admissions to psychiatric clinics derives from the traumatic consequences of child institutionalization and the lack of procedures and working tools to reduce challenging behaviors. Children raised in institutions experience a marked deprivation of social and environmental stimulation and this deprivation can disrupt brain development in ways that increase the risk for psychopathology. Institutionalization may increase the risk for psychopathology in that a life stressor factor at early age may induce epigenetic changes that can reprogram stress response system and may alter brain development trajectories.

**CEREBRAL ALTERATIONS DETECTED IN BRAIN IMAGING**

Current research has identified maltreatment-related differences in the architecture of the brain. Altered development of specific brain structures, including the limbic system and prefrontal cortex, is of interest given the established long-term difficulties in this population with cognitive and socioemotional functions thought to depend on these regions of the brain [7]. The brain imaging tests performed on institutionalized children show changes in prefrontal network connectivity responsible for: inhibitory control, behavior problems, impulsivity and attentional control [8]. Positron emission tomography (PET) studies have demonstrated that institutionalized children show reduced glucose metabolism in limbic regions, including the amygdala and hippocampus [9].

Subcortical volume alterations, cortical thickness abnormalities in prefrontal, parietal and temporal regions, and delay in maturation of the cerebral cortex suggest increased predictability of developing severe symptoms of ADHD in children exposed to institutionalized education. Atypical brain development related to institutionalization partially explains the association between institutional rearing and ADHD symptomatology. These findings suggest the presence of a neurodevelopmental mechanism linking institutional rearing with hyperactivity and impulsivity, two core features of ADHD. Deprivation in social and environmental conditions may become biologically embedded during early neurodevelopment and manifest as psychiatric problems later in life. Identification of neurodevelopmental mechanisms linking deprivation to psychopathology is critical for the development of psychiatric.
interventions to reduce the mental health consequences of adverse early environments.

In terms of explicit and implicit memory functioning it was observed that the amygdala volume is increased in institutionalized children while the hippocampus is smaller than normal. The amygdala plays a role in processing emotionally salient information both in terms of the formation of emotional memories and the guiding behavior based on emotional/threat-related stimuli through the attentional modulation of other areas of the cortex. While in general terms a dysfunction of the amygdala would be predicted to lead to deficits in the socioemotional domain of functioning. Neuroimaging studies have shown that in institutionalized children, in basolateral amygdala there is an increased neuronal cell adhesion concomitant with higher circulating levels of CRH. All these abnormalities cause what is called “learning by over prudence”: the abnormalities in amygdala function in institutionalized children develop adaptive mechanisms to ensure them that the body is prepared for future adversities in an environment perceived as threatening and deprived.

The relationship between early (infantile) experience and brain development during childhood and adolescence is of particular interest for children removed from early adversity and placed in an enriched environment. Given the plasticity of the developing brain and the regionally specific continuation of neurodevelopmental processes including synaptic pruning and myelination it is possible that the experience in the adoptive home may ameliorate the impacts of early adversity.

In summary, maltreatment is associated with a marked change in centrality of a relatively small number of cortical regions, which provides a theoretical mechanism through which maltreatment may act to increase the risk for substance abuse and mental illness. The cortical network organization of maltreated individuals may result in a diminished capacity to: regulate impulses and emotions, accurately attribute thought, intentions, or beliefs to others and be mindful of oneself in a social context. On the other hand, this network structure may lead to: heightened experience of internal emotions and cravings and a greater tendency to think about oneself and to engage in self-centered mental imagery. This certainly fits in with the knowledge that psychotherapies have been designed to enhance emotional regulation [10], correct misconceptions about self and others [11], diminish focus on internal feelings [12], and deceneter from harmful self-centered thinking [13].

**DELAYED MATURATION IN BRAIN ELECTRICAL ACTIVITY**

Typical maturation throughout development as well as atypical developmental patterns, including various types of psychopathology, have previously been associated with patterns of EEG activity including greater contribution of specific frequency bands [14]. The three frequency bands most relevant for the current discussion are beta (13–20 hz), alpha (7–12 hz), and theta (4–6 hz). As children age, alpha and beta frequencies increasingly contribute to the EEG signal while theta decreases [15]. There are many possible explanations for this observation. One possible explanation is that the structural integrity of white matter tracts is responsible for modulations of alpha frequency; as white matter integrity increases linearly during development, so do alpha contributions to EEG signal. Increased alpha and beta frequency contributions coupled with decreased theta contributions have been associated with increased attention in patient populations.
Research has shown that, in the case of institutionalized children, there is a weaker EEG signal compared to typical children [16]. The main EEG alterations refer to a higher electrical activity in frontal regions of the right hemisphere toward the left hemisphere (left region is activated on positive emotions and promotes pro-social behavior, the right hemisphere is activated by negative stimuli and underlies withdrawal and avoidance behavior). Significant reduction of alpha rhythm and increased frequency in frontal and temporo-occipital derivations are other factors which demonstrate the delay in cortical maturation in these children.

These findings generated two important conclusions. First, there appears to be a sensitive period for the development of neural structures underlying increased alpha power in the EEG signal, with amelioration of environment before the age of two being critical for remediation. Secondly, although this developmental “catch up” was made possible by placement into foster care before the age of two, it required years of exposure to foster care in order to emerge.

**COGNITIVE FUNCTION**

The effects of institutionalization on cognitive functioning have been well-documented. All the research data underlie the observations that previously institutionalized children had IQ deficits relative to never-institutionalized children.

Charles Zeanah reported in 2014 [17] that the average IQ in children who spend all their childhood in a Romanian institution is around liminary values, those introduced in the foster care system after the age of 2 recover very little over this figure; however, those who are entrusted to foster parents before the age of two can recover in terms of cognitive status until around IQ 100.

In addition to cognitive changes, it has been observed that there are a lot of social function deficits in children exposed to institutionalization. Kreppner and colleagues compared functioning across seven areas in previously-institutionalized adopted children and adopted children not exposed to institutionalization [18]. Institutionalization was associated with deficits in general cognitive function, a quasi-autistic syndrome, and disinhibited attachment. The quasi-autistic syndrome was identified using parent interview and included behaviors such as avoiding eye-to-eye gaze, difficulties forming selective friendships, deficits in empathy and emotional reciprocity. Disinhibited attachment involved indiscriminately friendly behaviors, including displays of attachment-like behaviors with unfamiliar adults or willingness to leave with unfamiliar adults. This cluster of problems reflects deficits in social-cognitive functioning.

Previous research has identified an association between lower levels of motor proficiency and lower full-scale IQ [19]. One interpretation of these findings is that early experiences lead to changes in brain development that affect both cognition and motor skills by affecting overlapping neural networks. These networks may be affected to different degrees depending on the nature of the child’s experiences. In other words, aspects of both IQ and motor skills may act as markers for the extent to which brain development in particular areas has been affected or preserved.

Although the cerebellum has traditionally been thought to coordinate predominantly motor activities, more recent work has suggested that it also coordinates cognitive activities in both adults and children [20]. Cerebellar development may possibly mediate both aspects of cognition and motor skills, and deprivation may affect cerebellar development.
Of note, children with a history of early psychosocial deprivation have smaller superior-posterior cerebellar lobe volumes, and superior posterior lobe volume mediates neuropsychological test performance differences between groups of post-institutionalized vs typically developing children, with larger volumes associated with better outcomes on tests of memory and planning. The superior-posterior lobes also are known to have a “somatotopic map” that is activated particularly during complex movements.

Published data on motor development in populations of institutionalized and previously institutionalized children found significant effects on motor development related to institutionalization. In children living in Romanian institutions without overt neurologic disabilities, the mean percentile rank was <6% for both gross motor and fine motor skills when tested at a mean age of 2.4-2.6 years. These findings persist after adoption; a study of international adoptees found gross motor delays in 33% and fine motor delays in 40% [21].

DISCUSSIONS

Most of the undesired behaviors of institutionalized children do not stem from the labels that those children receive very often as being "rude" or "malevolent", but from the brain dysfunctions caused by severe social and environmental deprivation, increasing the risk for psychopathology. In this article we have tried to emphasize on the fact that developmental trajectory of these children is significantly improved if they are integrated in families before the age of 2. The investment in families is more beneficial for their neuropsychomotric development than keeping those children in institutions. Children with frontal electroencephalography asymmetry get to experience major effects in response to negative emotional stimuli in adulthood.

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Volume 3, Issue 3-4, July- December, 2015


