Chapter 9
Institutional deprivation and neurobehavioral development in infancy

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Introduction

Institutional care during infancy often deprives children of the social interaction, environmental experiences, and the nutrients needed to promote healthy development. Prolonged institutionalization is associated with deficits across cognitive, socioemotional, and physical domains. However, the poor levels of functioning observed while children are in institutional care are not permanent. Research has demonstrated that removal from depriving environments, especially early in life, is associated with a remarkable rebound in many domains. As such, it is impossible to discuss the impact of institutional care in infancy without also focusing on neural plasticity and the capacity of young children to rebound if their conditions improve. On the other hand, there is evidence for sensitive periods for development in some domains, such that despite improvements following removal from deprived conditions, impairments and delays continue to be observed for years postinstitutionalization. Thus, children who were placed in more enriched environments following institutional care serve as models of the potential and limitations of plasticity in early childhood.

Before discussing evidence for sensitive periods and plasticity following early institutional care, several principles of development that are pertinent to this research must be discussed. First, longer periods of deprivation are related to poorer outcomes, and earlier removal from the depriving environment is generally related to better long-term outcomes and greater plasticity. This principle likely has to do with the timing of brain development, which is protracted across childhood with sensory and primary association areas developing first followed by areas that govern higher order abilities. Thus, longer durations of institutional care likely coincide with the rapid development of a greater number of neural systems than a shorter period in an institution. Likewise, earlier placement into an enriched environment increases the likelihood that rapidly developing systems will be positively stimulated by necessary environmental inputs.

Second, it has so far not been possible to isolate what aspects of institutional care are responsible for certain outcomes, and it is likely that multiple factors, including physical, chemical, social, and nutritional factors, are interacting to produce the phenotype. While it may be tempting to ascribe certain behavioral traits to a particular cause, it is impossible to tease apart the effects of so many interacting influences in the institutional environment. We have previously noted, however, that cognitive and language development proceeded on pace in institutions that served as model, training institutions in Britain over a half century ago (Tizard...
and Joseph 1970). These institutions provided children with excellent nutrition, high levels of stimulation, adult:child ratios about 1:3 or 1:4, multi-aged small groups that were more family like, and lots of social interaction with adults and children. Yet, staff turnover was high as nurses came to be trained and left for permanent jobs, and emotional development and behavior problems emerged and were persistent long after the children were placed in families (Hodges and Tizard, 1989). Thus, we concluded that nutrition and stimulation seem to be critical for cognitive and language development, but that emotional development is more strongly influenced by the presence and availability of relationships with a consistently available, supportive adult (Gunnar, 2001).

Third, individual differences in functioning often result even after experiencing similar environments. Although some children are quite sensitive to harsh early environments, others are resilient and either adapt successfully in the face of adversity or rebound more effectively once conditions improve. Differences in genetics may partially explain individual differences, but there are also a number of psychosocial factors involving how other people respond to the child and chance factors (e.g., a caretaker takes a particular shine to a child and provides them with more stimulation) that contribute to risk and resilience. Additionally, in studies of internationally adopted children who come from many different institutions, measuring the quality of preadoption conditions is difficult and of unknown reliability as it is based on parent report of what they were allowed to see.

Fourth, the particular stages of brain development that are underway during periods of institutional care must be considered when trying to understand sensitive periods of development and what functions may be most affected. Additionally, disruptions in functioning associated with early institutionalization should be studied together with the underlying brain regions and neural networks that map onto each particular domain. It must be noted that institutional care may have direct and/or indirect effects on each region of the brain and social/cognitive domain. The prefrontal cortex is a prime example of a brain region affected by institutional care both directly and indirectly as it develops rapidly early in life when institutionalization is most likely to occur, making it more susceptible to environmental perturbations. The prefrontal cortex is also a “hub-region” for coordinating information across the brain (Gao et al., 2009), meaning that it may be particularly at risk for indirect effects of institutional care on associated brain regions. For example, during the first year of life, the putamen shows the fastest growth rate in comparison to all other areas of the brain (Choe et al., 2012). As the putamen scaffolds the initiation of voluntary movement and environmental learning, and shares expansive connections with the prefrontal cortex, any damage to the putamen sustained during early life may negatively affect the development of the prefrontal cortex. In addition, larger effects could unfold over time in regions that are quickly developing during the period of deprivation (Nishida et al., 2006). On the other hand, the more we learn about the development of regions like the prefrontal cortex, the more we realize that these regions, while once thought of as late developing, are active and serve important functions during infancy. Thus, there may be more direct influences of stimulus deprivation on what were once thought of as only “late developing” regions (Kolb et al., 2012).

There is increasing evidence for sensitive periods of development, during which the
experience of institutional care or placement into an enriched environment has lasting effects on functioning. Nonetheless, while it would be very helpful to be able to differentiate duration of deprivation from the timing of deprivation, because most children arrive in institutional care at birth or shortly thereafter, timing and duration are typically too highly correlated to disentangle. This complicates sensitive period analyses, leaving the field with suggestive but far from conclusive evidence.

Fifth, unlike a deprived environment, which promotes plasticity that may reduce the potential for positive development, an enriched environment promotes plasticity that supports positive development by stimulating the brain with necessary social and sensory inputs. Although catch-up in certain domains may not be complete, the vast majority of research indicates that children who have been placed into adoptive or foster care homes outperform those who still live in institutions (van IJzendoorn and Juffer, 2006). Thus, relieving conditions of deprivation in order to support healthier development is the direction of policy advice, while whether or not this means removal from institutions depends on the availability of an infrastructure that supports the availability of safe, supportive family care arrangements (McCall, 2011).

Unfortunately, institutions that provide care for orphaned or abandoned children are unlikely to disappear in the near future, so research and interventions targeting institutions around the world are necessary to aid children's development despite unfavorable circumstances. In addition to improving children's outcomes, attention to within-institution interventions, can provide insight into the factors that promote psychosocial and neurobiological recovery in institutionalized children, which contributes valuable information about the nature of human development and necessary factors for healthy functioning.

The current review will cover cognitive, emotional, and behavioral systems impacted by early institutional care as well as neural systems, as evidenced by the use of imaging technology and electrophysiology. Impacts on stress-mediating systems such as the hypothalamic-pituitary-adrenal (HPA) axis and relatively recent research on genetic moderation of outcomes and epigenetics will be discussed as these are expected to relate to physical and mental health outcomes. Finally, we will discuss sensitive periods of development, postinstitutional factors affecting outcomes (e.g. parenting and attachment), and the plasticity of brain and behavioral systems following early intervention. Implications of studying children within institutions, children placed into foster care or adopted into families, and those undergoing psychosocial or nutritional interventions will be discussed in relation to what these groups can tell us about institutionalization and the human condition. Comparisons to children experiencing other forms of adversity will be discussed in order to understand the specific sequelae of institutional care and how research on children who have experienced institutionalization can be applied to other groups facing adversity.

**Cognition**

General intelligence and higher order cognitive skills (executive function) are negatively impacted by time spent in institutional care, and recovery following institutional care varies by
the cognitive domain affected and the brain regions rapidly developing during the period of institutionalization. A meta-analysis of 75 studies reported an effect size of $d = 0.74$ for the effect of institutionalization on IQ between children living in orphanages versus those raised in their families, which is on average a 20 point IQ difference (Van IJzendoorn et al., 2008). The Bucharest Early Intervention Project (BEIP) has provided valuable insight into the effect of institutional care on cognitive function. The BEIP followed institutionalized children randomized into foster care or care as usual, which initially meant continued institutional care. Among other measures, the BEIP assessed cognitive outcomes. At 54 months of age, children who were placed in project-supported foster care or who were never institutionalized performed better on cognitive tasks than the “care as usual” children (Nelson et al., 2007). Additionally, those children who were the youngest at foster care placement showed the greatest improvement in cognitive functioning, suggesting a sensitive period for the development of general intellectual abilities and that early placement out of institutions aids plasticity following adversity (Nelson et al., 2007). These effects remained constant through 8 years of age and IQ recovery was particularly evident for children who remained with their original project-supported foster care families (Fox et al., ). The latter finding suggests that stability following early institutional care may enhance plasticity following removal from the institution. Finally, for the most impaired, general cognitive abilities may continue to improve long after placement in an enriching home. Rutter and his colleagues noted continued, gradual improvement in IQ into the adolescent years for postinstitutionalized Romanian children whose Denver developmental quotients averaged around 50 at adoption (Rutter et al., 2010).

Executive function skills are particularly affected by institutionalization, likely reflecting the sensitivity of the prefrontal cortex to early experiences (e.g. Kolb et al., 2012). As early as 1 year after adoption, after controlling for IQ, postinstitutionalized children show deficits in several aspects of executive function (EF), including working memory, cognitive flexibility, and inhibitory control (Hostinar et al., 2012). Lower quality of institutional care and less time spent with the birth family before institutional placement predict poorer EF performance (Hostinar et al., 2012), which supports the hypothesis that greater severity and duration of deprivation are related to altered or impaired neurodevelopment. Evidence from the Minnesota and Wisconsin International Adoption Studies (Pollak et al., 2010) and BEIP studies (Bos et al., 2009) indicates that children who experienced a period of early life institutional care continued to perform more poorly for years after removal from institutional care on executive function and visual memory tasks than family reared children. However, after controlling for confounding factors such as birth weight, head circumference, and length of institutional care, children randomized into the foster care group in the BEIP study performed better compared to children in the care as usual group (Bos et al., 2009). Evidence that those randomly assigned to living in families perform better than those randomized to care as usual may highlight the potential for plasticity in executive functions following early deprivation. Alternatively, improved care after deprivation may only prevent children from further declines in functioning in certain domains.

All executive functions may not be equally affected by early institutional care. While children experiencing early institutionalization perform poorly on many executive function tasks, they
do remarkably well on planning and sequencing tasks such as Tower of London (Bos et al., 2009; Pollak et al., 2010). Alternatively, declarative memory, especially recall following a delay, appears to be impaired in postinstitutionalized children compared to never institutionalized children (Kroupina et al., 2010). These findings suggest that precise neural circuits underlying executive functions are affected or are less capable of recovery/compensation once the child is removed from deprivation rather than all circuitry supporting functioning on EF tasks. Given problems with executive functions, it is no surprise that children who spend their early years in institutional care are at high risk of being diagnosed with attention deficit, hyper-activity disorder (ADHD; Walshaw et al., 2010). Indeed, the aspects of EF affected in postinstitutionalized children overlap extensively with both the aspects that differ for children with ADHD (i.e., inhibitory control and working memory), while those spared (planning and set-shifting, see Pollak et al., 2010) also seem to be spared in ADHD (Walshaw et al., 2010).

Early nutritional status is also related to attentional outcomes in postinstitutionalized children. Greater ADHD symptoms in postinstitutionalized children 2.5–5 years postadoption are related to more severe iron deficiency at adoption and longer duration of institutional care (Doom et al., 2015). Unfortunately, postinstitutionalized children do not show reductions in ADHD symptoms over time (Doom et al., 2015). This finding suggests that while IQ in postinstitutionalized children generally improves over time, attentional problems do not show the same pattern of recovery postadoption.

Language is another cognitive domain that is affected by early institutional care but shows significant recovery following improvements in the environment. There may be a sensitive period, however. Work by the BEIP group revealed that children placed in families before the major spurt in word learning (i.e., before 15 months) exhibited the same expressive and receptive language scores as never institutionalized children in Romania at 30 and 42 months (Windsor et al., 2011). However, those placed later remained delayed. Followed up at 8 years of age, a similar pattern emerged with a cut-point at before and after age 2 years on measures of word identification and nonword repetition, an index of phonological memory (Windsor et al., 2013). Notably, several studies have shown that the rate of language learning in children old enough to learn language is a sensitive early indicator of which children will recover in cognitive abilities more rapidly and which will continue to struggle years after adoption (Croft et al., 2007). Thus, language skills and areas of the brain that support language show resilience if the child is placed in a language-rich setting before age two and preferably before the burst in word learning that occurs around 15 to 18 months of age (Windsor et al., 2011).

Deficits in theory of mind have been reported in postinstitutionalized children. Children who spent part of their lives in an institution performed worse on a false belief task than children raised in their birth families, with over half performing at below chance levels even after controlling for verbal ability (Tarullo et al., 2007). Children adopted from institutions after 6 months of age show the greatest deficits in theory of mind (assessed by the Strange Stories task), and theory of mind and executive function difficulties are related to deprivation-specific problems such as ADHD symptoms, indiscriminate friendliness, and quasi-autism (Colvert et al., 2008). It appears that although both theory of mind and executive function may partially
mediate the relation between institutional care and deprivation-specific problems, neither fully accounts for the association (Colvert et al., 2008).

Not all of these cognitive outcomes can be attributed to stimulus and social deprivation. Nutritional deficiencies may affect cognitive outcomes as well as neural plasticity during recovery. For example, severity of iron deficiency at adoption is associated with lower IQ in postinstitutionalized children at age 5, while duration of institutional care is not (Doom et al., in press). In addition, children with more severe iron deficiency at adoption or who had spent more than 12 months in an institution before adoption showed the greatest improvements in IQ between 12 months postadoption to 2.5–5 years postadoption (Doom et al., in press). As a result, factors beyond social and physical deprivation should be studied in institutional care in relation to sensitive periods of development and later plasticity in cognitive outcomes.

**Emotion Processing**

Although researchers hypothesized that children raised in institutions may have difficulties with facial emotion processing due to lack of experience with consistent caregivers, the BEIP reported no differences between children in institutions and those raised in their biological families between 13 and 30 months of age in responding to peak facial expressions of emotion (Nelson et al., 2006). Differentiating facial expressions, however, is a less complex task than matching facial expressions to situations, something that reflects understanding of both the situations and the meaning of the facial expressions. Here, postinstitutionalized children may be delayed or impaired. A group of postinstitutionalized children compared to family reared children studied around 54 months of age showed difficulty in matching facial expressions to vignettes that reflected situations that would cause children to be happy, fearful, or sad (Fries and Pollak, 2004). These children did not show difficulty matching to angry facial expressions (Fries and Pollak, 2004). The specificity of findings for emotion recognition may be an early risk factor for emotional difficulties if children find it easier to recognize and contextualize angry compared to happy facial expressions. Further neurobiological evidence for altered emotional processing is discussed below.

**Emotional difficulties**

Although children reared in institutions early in life are often described as having emotional problems, including anxiety, depression and problems regulating emotional behavior, whether or not these problems are particularly associated with institutional care or not and whether they reach clinical levels varies with the child's age, the informant, the instrument used and the comparison group. In the BEIP study they used the Preschool Age Psychiatric Assessment (PAPA) and noted that at 54 months of age, 44.2% of those in the care as usual group were exhibiting clinical levels of internalizing symptoms, while only 22% of those placed in foster care were suffering with significant internalizing symptoms (Zeanah et al., 2009). In contrast, in studies using the Child Behavior Checklist (Achenbach, 1991) or the Rutter Behavioral...
Scales (Elander and Rutter, 1996), few have reported evidence in childhood that anxiety symptoms are higher in postinstitutionalized children than in children with other early adverse histories (Figure 9.1; Gunnar and van Dulmen, 2007; Juffer and van Ijzendoorn, 2005). However, when children themselves are interviewed (Wiik et al., 2011) and by age 11 regardless of the informant (Colvert et al., 2008), postinstitutionalized children are more likely to express anxiety disorders and/or preclinical levels of anxiety symptoms than are children from supportive backgrounds or inter-country adopted children arriving from foster care homes. It is not clear whether the PAPA is more sensitive to anxiety in young children or the BEIP children were more anxious.
Figure 9.1 Percentage of children adopted from institutional or foster care with CBCL scores of >61 in each domain. (a) Children adopted before 24 months of age. (b) Children adopted after 24 months of age. Regardless of type of care, children adopted later were more likely to express elevated behavior problems. Main effects of institutional care were only noted for attention and social problems. Adapted from Gunnar & van Dulmen, 2007. (See insert for color representation of this figure.)
What does seem clear is that emotional difficulties tend to increase with time since adoption, particularly into adolescence. We do not know why, but there are several possibilities that are not mutually exclusive. First, this could reflect sleeper effects. Thus, neural systems that were impaired early in life begin to produce disorder only with development when the need for those systems to regulate becomes developmentally critical. Second, it may reflect co-
morbidities with other problems exhibited by children who experience early deprivation, particularly those that impair school functioning and peer relationships. Parents may be able to scaffold both schoolwork and friendships while the children are young, but with adolescence parental scaffolding gets increasingly removed and deprivation-induced deficits may increasingly affect the child's academic and social standing, which in turn may create the context of significant emotional problems. Finally, in adolescence, issues of identity come to the fore that are very challenging for adopted children, particularly those from racial/ethnic minorities, as are many internationally adopted children. Problems grappling with these identity issues may contribute to emotional burdens that enhance emotional problems with time postadoption.

**Behavior**

A number of behaviors appear to be characteristic of children and adolescents who have spent a significant duration of time in an institution, with some behaviors becoming less frequent and severe over time and others becoming more frequent and severe. During the time of institutionalization, over 60% of Romanian children experience stereotypies (mean age 22 months), but the frequency of these behaviors decreased significantly over time for the children randomized to the foster care condition, especially with earlier placement and longer duration of foster care in the BEIP (Bos et al., 2010). Remaining stereotypies in the foster care group, but not in the care as usual group, were related to poorer language and cognitive outcomes (Bos et al., 2010). Other behaviors observed at the time of removal from Romanian orphanages include rocking (47%) and self-injurious behavior (Beckett et al., 2002). These behaviors declined in frequency over time, with 18% rocking and 13% self-injuring at 6 years of age. The primary predictor of these unusual behaviors was the duration of time in the institution before adoption (Beckett et al., 2002).

Altered social behaviors have been documented in children experiencing early deprivation, including indiscriminate friendliness and greater likelihood of insecure attachment (Chisholm, 1998), with longer periods in institutional care related to greater indiscriminate friendliness (Bruce et al., 2009). Although indiscriminate friendliness has been interpreted at times as an indication of the lack of an attachment relationship, more recent work now clearly shows that it is not an indication of a disordered attachment (Chisholm, 1998; Zeanah et al., 2002). If not an attachment problem, what is it? Chisholm (1998) argued that it is an adaptive behavior in institutional settings that is not extinguished when children move into more responsive care environments. Others have argued it reflects problems in maintaining appropriate social boundaries (Rutter, 2002), which is consistent with recent evidence that it is not just that postinstitutionalized children are overly friendly. They engage in behaviors, such as touching
complete strangers and crawling in their laps, that most family reared children rarely exhibit (Lawler et al., 2014).

Furthermore, although Zeannah and colleagues originally argued that indiscriminate friendliness did not reflect a general impulsivity because it was not associated with aggression (Zeannah et al., 2002), other studies that have examined attention regulation using neuropsychological tasks (Bruce et al., 2009) and attention and hyperactivity problems (Roy et al., 2004) have found significant associations. Thus the current thinking is that it does reflect problems in inhibitory control that results in the failure to appropriately regulate behavior to conform with social boundary expectations.

**Brain development**

To date there are no published studies of brain development in institutionalized children that have measured development over time. What we have is an emerging literature examining brain structure and function in middle childhood and adolescence of youth who were removed from institutional care when they were infants or young children (average age 2 years). As of yet we cannot say anything about recovery or rebound, although from the behavioral data we know improvement in function has occurred for many children. We can, however, identify systems that years postadoption are structurally and functionally different from what is observed in children who did not spend their early months and years in institutional care. We can also begin to examine effects that are correlated with how long children lived in institutional care.

Both human and animal studies strongly suggest that the prefrontal cortex is directly affected by a harsh early social environment. For example, in neonatal rodents experiencing maternal deprivation, increased rates of cell death in the frontal cortex have been reported (Zhang et al., 2002). Even small but stressful perturbations in the early environment, including brief handling periods multiple times a day, produce structural changes in the pyramidal neurons of the prefrontal cortex (Helmeke et al., 2001). In squirrel monkeys that have experienced intermittent maternal separation, an 8–14% increase in volume of the right ventromedial prefrontal cortex has been observed during adulthood (Lyons et al., 2002). Likewise, maternal deprivation in rhesus monkeys is associated with 10–11% increases in volumes of the dorsal medial prefrontal cortex and dorsal anterior cingulate (Spinelli et al., 2009). Overall, it appears that early social deprivation is linked to specific structural changes in the prefrontal cortex that persist into adulthood.

These findings in animal models have been translated to children experiencing institutional care. Consistent with cognitive delays reported in postinstitutionalized children, decreased prefrontal gray matter volume (Hodel et al., 2015) and alterations in prefrontal white matter (Sheridan et al., 2012) have been documented in formerly institutionalized individuals. Thus, placement out of institutional care and into foster or adoptive homes does not seem to completely ameliorate changes in prefrontal cortex development. In line with findings of poorer cognitive functioning in many formerly institutionalized children, both gray and white
matter volumes have been found to be smaller in formerly institutionalized compared to never institutionalized adolescents (Mehta et al., 2009). However, Mehta and colleagues reported no significant differences in hippocampal volume or mid-sagittal area of the corpus callosum after controlling for differences in total brain volume (Mehta et al., 2009). In contrast, examining postinstitutionalized youth from over 25 countries adopted from institutions into US families, our group noted significantly smaller prefrontal cortex volumes regardless of duration of institutional care, and smaller hippocampi that had a dose response association with institutional care duration (Hodel et al., under review). The BEIP also reported smaller cortical gray matter volume for children who had experienced institutional care, but cortical white matter volume was only smaller for the children in the care as usual group (Sheridan et al., 2012). As the group randomized to foster care did not differ from never institutionalized children in cortical white matter volume (Sheridan et al., 2012), it could be that cortical white matter volume in the brain experiences greater plasicity following an improvement in environment but gray matter volume continues to be affected throughout childhood.

Neural connectivity also appears to be altered in individuals who experienced early life institutional care. Adolescents who had experienced early deprivation were found to have a more diffuse pattern of connectivity in the right hemisphere, which is possibly the result of ineffective neural pruning and could be related to ADHD symptoms in this population (Behen et al., 2009). Additionally, alterations in the left uncinate fasciculus, which connects parts of the limbic system to the frontal lobe, appear to be present in children who had previously been institutionalized in Romanian orphanages, which may partially explain cognitive and socioemotional difficulties reported in many studies (Eluvathingal et al., 2006). Further alterations in white matter for children with histories of early deprivation include reduced fractional anisotropy across the frontal, temporal, and parietal lobes (Govindan et al., 2010). This finding included the uncinate and superior longitudinal fasciculi, providing additional evidence that alterations in neural connectivity between frontal and limbic regions may underlie behavioral difficulties. Further, these white matter changes were related to the duration of institutional care and to ADHD symptoms (Govindan et al., 2010), suggesting there are neural underpinnings connecting early experience to later behavior. A recent study reported more diffuse organization of white matter in the prefrontal cortex following institutional care and that this pattern was associated with neurocognitive deficits (Hanson et al., 2013a).

A study of postinstitutionalized children from Romanian orphanages reported decreased bilateral glucose metabolism in several areas, including the infralimbic prefrontal cortex, the orbital frontal gyrus, lateral temporal cortex, the amygdala, the head of the hippocampus, and the brain stem (Chugani et al., 2001). Reduced EEG α-power has been reported in children raised in institutions compared to those raised in their biological families, and this result is partially mediated by cortical white matter volume reductions (Sheridan et al., 2012). As a result, there appears to be both direct and indirect effects of early deprivation on the prefrontal cortex.

Animal studies of stress show that stress produces amygdala plasticity resulting in larger volume and enhanced reactivity to threatening stimuli (reviewed in Tottenham, 2012). Because postinstitutionalized children tend to be anxious and because of the animal work, significant
attention has been focused on whether amygdala structure is increased and function is heightened for children with early institutional care histories. Just as some postinstitutionalized children may have difficulties connecting facial expressions with the appropriate eliciting conditions, which may impair responding appropriately to others, some also respond more physiologically to emotional expressions, which may influence behavior in social settings. The results are mixed on structure but consistent so far for function. The mixed results for structure, with some reporting increased volume (Tottenham et al., 2010; Mehta et al., 2009), some decreased volume (e.g., Hanson et al., in press) and some no difference, may be because of both power issues and the challenge of imaging the amygdala. Regardless of whether there is an impact on amygdala volume, the functional studies strongly suggest greater response to threat stimuli. Recent findings in postinstitutionalized children indicate that fearful faces during the Emotional Face Go/Nogo task elicit heightened amygdala responses compared to never institutionalized children (Tottenham et al., 2011). This increased amygdala activity is a mediator of the relationship between early deprivation and decreased eye contact during dyadic interaction, which may be related to socioemotional difficulties in these children (Tottenham et al., 2011). Further, for children with early neglect experiences, about half of whom were adopted from institutional care, threatening information elicited greater activation of the left amygdala and left anterior hippocampus than was noted for children without early neglect experiences (Maheu et al., 2010). Likewise, postinstitutionalized children do not exhibit decreases in ventral PFC activation to fearful faces that are observed in children reared in their birth families (Tottenham et al., 2011). Patterns of reactivity in fearful versus neutral faces in postinstitutionalized children more closely resemble typically developing adults, which may indicate accelerated development of the amygdala and other neural networks responsible for socioemotional processing (Tottenham, 2012). Consistent with neuroimaging results, postinstitutionalized children show a greater number of errors during tasks when negatively valenced faces are present but no differences for positively valenced faces, suggesting difficulty with processing and potentially with attention while negative social stimuli are present (Tottenham et al., 2010). These functional differences are consistent with heightened anxiety discussed earlier as well as with overall atypicalities in social functioning.

**Electrophysiology**

Electrophysiological measures suggest that early life institutional care alters patterns of neural activity. Several aspects of electrical activity have been examined. First, because internalizing symptoms have been associated with greater EEG activity over right than left frontal regions of the scalp (Davidson, 1998), EEG frontal asymmetry has been examined in institutionalized and postinstitutionalized children. No simple group differences have yet been reported; however, the BEIP group noted that typically developing family reared children showed a greater relative right hemisphere activation from 30 to 42 months, before shifting to the more common mature pattern of greater relative left hemisphere activation (McLaughlin et al., ). This was not observed for all institutionalized children who showed the greater relative right hemisphere activation pattern at older ages, suggesting a delay in maturation. The same delayed pattern of activity has been reported for studies of EEG power. With development, the power spectra
observed when the brain is at rest increases (Marshall et al., 2002). For infants sitting quietly, theta rhythms predominate. With development, this shifts to alpha. Several research groups have now shown that when children are in institutional care and soon thereafter, they show a larger percentage of theta rhythms in their resting EEG than children reared in families (Marshall and Fox, 2004; Tarullo et al., 2011). These patterns correlate with attention problems (McLaughlin et al., 2010) and indiscriminate friendliness (Tarullo et al., 2011), both strongly associated with early institutional care as noted above. Importantly, once placed in a supportive home environment, patterns of EEG power show marked development and over time become comparable to those of never institutionalized, family reared children (McLaughlin et al., 2010).

Studies using event-related potentials (ERPs) have also noted differences between children reared in institutions early in life and those reared in family settings. The BEIP group noted that ERPs in responses to faces depicting emotion (i.e., P1, N170, and P400) had smaller amplitudes and longer latencies for care as usual children than for family reared children, with those placed in foster care falling in between, suggesting some recovery (Moulson et al., 2009). Several groups have examined ERPs while children perform tasks that require response inhibition and conflict monitoring (e.g., go/no-go and flanker). The BEIP group reported that children removed from institutional care and placed in foster care showed improved P300 responses compared to the care as usual group but that were still not as good as those of children in the never institutionalized group (McDermott et al., 2013). Likewise, in another study, postinstitutionalized children exhibited smaller attentional responses (N2) and reactions to errors (error-related negativity, ERN) than did never institutionalized, family reared children even after 5 or more years living in enriching family settings (see Figure 9.2; Loman et al., 2013). Thus, the ERP data supports the behavioral findings that early deprivation impairs attention regulation and while improvements may be seen, children frequently continue to struggle with their ability to regulate attention for years following adoption.

![Figure 9.2](image_url) Error-related negativity averaged across Flanker and Go-NoGo (counter-balanced) tasks for postinstitutionalized (PI) children and non-adopted (NA) children raised in families comparable to those who adopt children internationally. Bars reflect standard error of the mean. Adapted from Loman et al., 2013.
**HPA activity**

The HPA axis serves as a stress-mediating system that prepares the body for physical and psychological challenges. After the stress period has passed, the axis returns to baseline. Evidence from children who have experienced early institutional care indicates that early deprivation has lasting effects on HPA regulation, which in turn is related to subsequent behavior problems. Toddlers living in an institution have demonstrated a flattened diurnal cortisol slope with lower morning and elevated evening cortisol (Carlson and Earls, 1997).

Postinstitutionalized children have demonstrated mixed results. One study reported higher cortisol levels over the day for children adopted in the early 2000s from Romania (Gunnar et al., 2001). All the other studies have reported that while some children exhibit a normally steep diurnal cortisol rhythm, other children exhibit a blunted or flattened rhythm either due to lower morning or higher evening levels, or both (Johnson et al., 2011; Kertes et al., 2008). This is also true not only for postinstitutionalized children but also for adults adopted from conditions of deprivation as children (van der Vegt et al., 2009). Notably, a recent longitudinal study of internationally adopted children demonstrated that poorer social care, as opposed to physical care, prior to adoption was related to a more flattened diurnal cortisol slopes that persisted over a 2-year period and mediated behavioral problems reported by parents (see Figure 9.3).

![Figure 9.3](image.png) Predicted diurnal cortisol across the day for postinstitutionalized children among high- and low-quality social care in institutions. Graphs depict 1 SD above and below the mean of the social care construct as an illustration of high- and low-quality social care. Kalsea J. Koss, Camelia E. Hostinar, Bonny Donzella, Megan R. Gunnar 2014, Figure 2. Reproduced with permission of *Psychoneuroendocrinology*, Elsevier.
Genetic moderation and epigenetics

Research on single nucleotide polymorphisms has revealed significant moderation of outcomes by genotype. For example, children with the dopamine transporter gene (DAT1) risk allele and who had spent more time in an institution showed the highest levels of ADHD symptoms, and the association strengthened over time (Stevens et al., 2009). Likewise, children with the risk allele of the BDNF gene showed the greatest attention problems when adopted later and fewer attention problems when adopted earlier (Gunnar et al., 2012). Thus, individual differences in risk and resilience following institutionalization may be partially explained by genetic moderation.

Epigenetic regulation and telomere length have also been studied in relation to institutional care. A study of currently institutionalized children reported greater DNA methylation compared to children raised in their biological families, particularly in regions regulating cellular signaling and the immune response (Naumova et al., 2012). To date, no studies have reported differences in epigenetic regulation years after institutional care, so it is unclear whether there is plasticity in the epigenome following early adversity. DNA telomere length, which is a marker of cellular aging, has also been associated with institutional care. During middle childhood, children with histories of institutional care showed shorter relative telomere length compared to children raised in their biological families (Drury et al., 2012). Notably, in that study girls with longer times in institutional care in infancy and boys with greater times in institutional care including the preschool years had shorter telomeres in middle childhood. Future research is needed to determine whether these genetic alterations are associated with accelerated aging and physical health problems across development.

Evidence for sensitive periods

A large body of evidence suggests the presence of sensitive periods for the development of a number of cognitive, social, and neurobiological domains. The timing of these sensitive periods appears to differ by domain, which is unsurprising considering the varied developmental timing of distinct neural circuits and brain regions. For example, there appears to be a sensitive period for IQ at around 2 years of age, which may reflect the importance of language development in supporting the development of general intelligence (Nelson et al., 2007). Problems with executive functions, attachment, indiscriminate friendliness, and emotional problems may have a different sensitive period. Two studies of Romanian adopted children have suggested that postinstitutionalized children are at heightened risk for problems in these spheres if they are adopted beyond 4 to 6 months of age (Fisher et al., 1997; Kreppner et al., 2007). However, the children in those studies were adopted from conditions of extreme and global deprivation. Children adopted more recently following improvements in institutional care (i.e., adequate physical care, still low social care) appear to have executive function skills comparable to a normative sample when adopted before 9 months of age (e.g., Merz et al., 2013). Broadly, it appears that deprivation very early in life (before 6 months of age) is associated with relatively few lasting impacts compared to infants who experienced
more prolonged periods of deprivation. When during infancy long-lasting deficits emerge in different arenas may depend on the timing of maturation of the neural circuits involved in the behavior domain and the severity of the deprivation, with more severe deprivation reducing the age at which full recovery is possible with adoption.

Factors modifying postinstitutional outcomes

Early life social stimulation in the form of sensitive and responsive caregiving may be one of the most important factors influencing subsequent development. As demonstrated by the literature reviewed above, institutional care, which is often characterized by a lack of consistent caregivers, results in a number of social and cognitive deficits. Fortunately, social stimulation and consistent caregiving provided by adults after institutional care are likely the most important factors guiding recovery, which is why placement into an adoptive or foster care home early in life results in more positive outcomes.

The BEIP demonstrated that placing institutionalized children into project-supported foster care dramatically increased the percentage of children who were securely attached to a caregiver (Smyke et al., 2010). Compared to the 18% of securely attached children living in institutions at 42 months, 49% of children placed in foster care and 65% of never institutionalized children showed secure attachment (Smyke et al., 2010). In addition, attachment was shown to mediate between the experiences of institutional care and psychopathology in children randomized to foster care placement in the BEIP study (McGoron et al., 2012). Recent research demonstrates that attachment relationships develop relatively quickly between postinstitutionalized children and caregivers, although children who spent longer periods in an institution took longer to form attachments, and postinstitutionalized children were more likely to have a disorganized attachment pattern than were children reared in their birth families (Carlson et al., 2014). Thus, for most children, institutional care does not appear to disrupt attachment formation long-term after placement into homes with more consistent caregiving, but it may make it difficult for children to form organized and secure attachment relationships.

Researchers are beginning to ask whether and how the quality of parenting postadoption influences the development of postinstitutionalized children and youth. Of course, if children who demonstrate problems have parents who exhibit less positive parenting behaviors, it might be that the problems displayed by the children are affecting parental behavior and not vice versa. This seemed to be the message from an analysis of Romanian children adopted into the United Kingdom. Here the researchers noted that as the children's cognitive functioning improved over time, parents were observed to use more positive parenting behavior (Croft et al., 2001). Nonetheless, most proposed interventions for families with internationally adopted children focus on improving parenting (e.g., Juffer et al., 1997). Parenting interventions developed from research on children in foster care may be useful for promoting the development of attachment between postinstitutionalized children and caregivers. For example, the Attachment and Biobehavioral Catch-up (ABC) intervention has demonstrated effects on stress system regulation and fewer behavior problems for children living in foster care (Dozier,
et al., 2006; Dozier et al., 2008). An intervention based on the ABC program is currently being tested with families who have adopted internationally (Dozier, personal communication).

Improving parenting may be important in supporting the postadoption development of internationally adopted children, but it may not address all of the issues in cognitive and social functioning that were noted in this review. For issues with attention problems, inhibitory control, and sensitivity to threat, strategies that help “retrain the brain” to enhance appropriate neural circuits may be needed.

**Interventions and evidence for plasticity**

While interventions for children experiencing institutional care can provide insights into the elements of deprivation that influence cognitive and social development, the major thrust of these interventions often are to show that it is institutional deprivation and not something inherent about the children that is producing their poor functioning. When this is shown, it encourages countries to change the ways that they are caring for young children who are wards of the state. Certainly, when viewed as an intervention, adoption has massive effects on children’s functioning. Indeed, a meta-analysis of adoption studies shows differences in IQ between adopted children and those who stayed in the institution with an effect size of 1.17 (Van IJzendoorn et al., 2005). Improvements in school achievement and attachment security have also been reported at approximately the same effect size as IQ, and adoption produces the best outcomes for children when it occurs before 12 months (Bakermans-Kranenburg et al., 2008). Foster care is a better alternative than institutional care for children without permanent parents, as demonstrated by the BEIP, especially if placement occurs before 24 months (Nelson et al., 2007). However, effect sizes for cognitive outcomes are better for adopted children than for children placed in foster care, whose cognitive outcomes have effect sizes of 0.62 at 42 months and 0.47 at 54 months (Nelson et al., 2007).

While foster care may be better than institutional care, it can only exist if there is a strong infrastructure to support it; thus, intervening to improve the care children receive within institutions and show that it has effects on outcomes are still valuable. Within-institution interventions have included additional tactile, auditory, and visual stimulation by adult caregivers, which have been shown to produce generally positive effects on development.

In the St. Petersburg-USA Orphanage Research project, researchers tried two strategies to improve children’s outcomes. One orphanage was provided with trainings for caregivers plus structural changes such as ensuring that individual children are cared for by a few consistent caregivers. Another orphanage was given the caregiver training only. The development of children in these orphanages was compared to that of children in a ‘care as usual’ orphanage. In nearly every assessment following the intervention, children in the orphanage with both training and structural changes performed better cognitively and socially than children in the training only or no intervention conditions, suggesting that a combination of educated caregivers and changes that allow for consistent caregiving is best to promote plasticity. As the intervention was largely social in nature, effect sizes were larger in the social domain,
including more positive social behaviors for children in the training plus structural changes group. However, cognitive effects were also observed, indicating cross-domain effects are likely for within-institution interventions. Consistent with other institutional interventions, longer exposure to the interventions promoted positive development in typically developing children. In addition, the intervention prevented declines in children with disabilities, and effect sizes were often larger for children with disabilities. This finding suggests that children who are developmentally delayed have the most to gain from improvements in care and demonstrate the most plasticity following early deprivation. This indicates that the treatments provided during the intervention period would need to become a permanent part of institutional care in order to produce lasting positive impacts on children's development.

Nutritional interventions have been implemented in certain institutions in order to prevent the cognitive and socioemotional sequelae of malnutrition and nutrient deficiencies. For example, the SPOON Foundation has worked to improve nutrition and feeding practices in orphans across the world. Longitudinal research is needed to understand the neurobiological correlates of early nutrition supplementation in institutionalized children.

Within-institution interventions focusing on increasing sensory and social stimulation, as well as improving nutrition, suggest that all three of these components of early deprivation have individual effects on development and should be targeted in future comprehensive interventions. Sadly, in general, gains obtained when institutional conditions are improved often fade when conditions go back to the way they were before the intervention (reviewed in St. Petersburg–USA Orphanage Research Team, 2008). This indicates that for positive gains to become permanent, overall care needs to permanently improve. Indeed, the intervention literature indicates that while adoption is the best intervention for children living in institutions, interventions that include both trained caregivers and structural changes over a prolonged period of time produce the best outcomes for children, especially when implemented early in life while the brain is rapidly developing.

**Comparisons with other forms of adversity**

Children experiencing other forms of adversity, including maltreatment and poverty, demonstrate similarities to children who experienced early institutional care. Global cognitive impairments have been noted across experiences for these children (reviewed in Pechtel and Pizzagalli, 2011). Like children who have experienced institutional care, children who have been maltreated have higher rates of internalizing and externalizing problems, including increased rates of ADHD symptoms (Cicchetti and Valentino, 2006). Children adopted from institutional care show the greatest similarities in social behavior to children who have experienced early life neglect. Greater likelihood of insecure attachment and indiscriminate friendliness have been reported for children adopted from Romanian institutions (Chisholm, 1998), which is similar to social patterns observed in children raised by neglectful parents (e.g., Erickson and Egeland, 2002). Children in poverty also show cognitive deficits similar to children with institutional care experiences, such as lower IQ and poorer school achievement (Bradley and Corwyn, 2002). Further, children in poverty have an increased likelihood of
psychiatric disturbances (internalizing and externalizing) and social functioning problems, which are observed in postinstitutionalized children (Bradley and Corwyn, 2002).

Likewise, similar patterns of brain development have been reported for children experiencing a variety of different types of adverse care in early development. Thus, reduced brain volume is associated with early institutional care, but this is also true for poverty and maltreatment (Cicchetti and Valentino, 2006; Hanson et al., 2013b). Larger ventricles and reduced hippocampal volume have been observed for maltreated children (Cicchetti and Valentino, 2006), and we have recently noted this for postinstitutionalized children (Hodel et al., under review). One of the reasons why outcomes are not as distinct as we might initially expect for children with these different backgrounds is that they share many similar risks to their development, from prenatal stress and teratogen exposure to neglect of physical and emotional needs to deficits in stimulation. It is difficult to parse out which factors may be contributing to a certain outcome without experimentation (e.g., the BEIP random assignment). In addition, more research following adults who experienced institutionalization as children will provide greater insight into potential development of psychopathology and other socioemotional outcomes in adulthood, which can then be compared to other groups experiencing adversity.

**Individual differences and resilience**

One theme that cuts across all of these areas is that while some children are negatively affected by adversity, others seem to do much better. The study of resilience in children who have experienced institutionalization closely parallels the literature on maltreated children, citing that supportive relationships and certain characteristics of the child promote resilience against adversity (Cicchetti 2010). Important differences between the groups do exist in terms of resilience as it is unlikely that postinstitutionalized children, who are usually adopted into well-resourced, highly motivated families, experience heightened continued life stress in the same way that maltreated children do. Thus, studies of resilience in postinstitutionalized children may inform studies of maltreated children, particularly if adversity is limited to early life. Differences between institutionalized children and those experiencing other forms of adversity may help researchers narrow down what outcomes follow each type of adversity as well as the duration and timing of adversity.

**Conclusions**

Research on the neurobiological correlates of infant institutionalization shows lasting effects of experiences during the first years of life (see **Figure 9.4** for a summary). However, studies of children removed from these harsh early environments provide reason for optimism, as there is significant plasticity in cognitive, emotional, and behavioral outcomes following placement in a more enriched environment. Research involving postinstitutionalized children allows researchers to ask questions about the role of a specific time period on subsequent development, and the timeline of recovery for certain systems can be explored. Importantly, we can also study the factors that promote plasticity and recovery from early life stress. One of the
best ways to promote recovery is removal from the depriving environment and placement into a loving family whether through adoption or well-supported foster care. Reuniting the children with their families may also work if the problems that led to institutional placement are addressed. Although there have been some within-institution interventions that have demonstrated success, especially when implemented early in life, further work must be done to improve pre- and postnatal care for children in institutions to ensure the best outcomes possible.

**Figure 9.4** Potential effects of early institutional care. These effects are not specific to institutional care, as they may also follow other forms of early adversity. The duration of institutionalization increases the risk of these outcomes. (See insert for color representation of this figure.)

In general, longer periods of deprivation are related to poorer outcomes, and placement into a more enriched environment is best, especially if it occurs early in life. Evidence for sensitive periods differs by the domain studied and the severity of the deprivation. Likewise, certain domains show greater plasticity following adoption or foster care than others. Interventions in this population have demonstrated that improvements in the environment may affect disparate aspects of development. For example, the St. Petersburg study was largely a social intervention, but researchers observed improvements in cognition as well as in social functioning. Findings such as these should influence researchers to study how closely cognitive and social development are related and to probe the potentially shared neural circuitry involved in cognitive and social recovery following deprivation.
Effects of early institutional care are generally consistent with other forms of early adversity. However, unlike other groups of children who experience significant adversity early in life, children who are adopted from institutional care experience a marked and permanent improvement in care, which can allow us more adequately to address questions of plasticity. Work in this population can also allow tests of interventions under optimal conditions of parent participation, before moving the intervention into populations where families may struggle to provide the support the intervention needs. Thus, research on this population may help other groups experiencing early adversity.

Beyond informing scientists about the neurobiological sequelae of early institutionalization, research on children who have experienced institutional care provides valuable information about human nature and development. First, what does early institutional care tell us about human nature? Is institutionalization one extreme on a continuum of social experiences, or is it beyond any experience that a person should have? Research documenting severe delays in functioning in some children would suggest that this is a unique situation for humans, but there are many children who remain resilient in the face of deprivation, which may suggest an extreme end of a continuum that some are able to overcome. Further, should we view alterations in functioning as adaptation to a severely depriving environment, or are these changes maladaptive responses even in the institutional context? One might argue that behaviors such as indiscriminate friendliness may help children gain social interactions that could promote survival in an institution although not necessarily adaptive once in an adoptive family. However, cognitive deficits such as lower IQ do not appear to be adaptive in different contexts, so the argument about the adaptiveness of particular outcomes may be domain-specific. In addition, how long does plasticity occur following removal from institutional care? It likely depends on the timing of the new placement and the severity of deprivation, but this question is important to those interested in neuroplasticity. For example, is the window for plasticity open long enough to allow the adopted child to adapt to their new environment? Ideally, the window would remain open long enough so that children can adapt to their new enriched environment to prevent a mismatch between the child's adaptive skills and their new environment. However, persisting alterations in cognition and behavior suggest that while plasticity may occur for some skills, there may be mismatches between behavior and environment for other capacities. Finally, what factors are essential to human development? The cognitive and social difficulties experienced by children in severely depriving environments suggests that minimum requirements for healthy human development are consistent interactions with sensitive caregivers and a variety of interactions with sensory stimuli. This information is vital for institutional staff as well as any person caring for young children.

Overall, research on children who have experienced early deprivation indicates there are specific cognitive, socioemotional, and neurobiological deficits due to institutional care but also significant opportunities for plasticity following improvements in the environment. Future research in this area should focus on identifying sensitive periods of development for specific domains as well as factors that promote healthy development both within the institution and after placement into an enriched environment. As within-institution interventions and adoption
into loving families demonstrate plasticity following deprivation, knowledge gained from research on institutionalized children should continue to inform interventions that promote positive development.

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