Effects of early intervention and the moderating effects of brain activity on institutionalized children's social skills at age 8

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The present study examined the social skills of previously institutionalized, 8-y-old Romanian children from the Bucharest Early Intervention Project and the influence of attachment security and brain electrical activity (alpha power) on these skills. Participants included children randomized to an intervention involving foster care [Foster Care Group (FCG)], children randomized to remain in institutions [Care As Usual Group (CAUG)], and never-institutionalized children living with their families in the Bucharest community [Never-Institutionalized Group (NIG)]. A continuous rating of children's attachment security to their primary caregiver was assessed at 42 mo of age. When children were 8 y old, teachers rated their social skills, and the children's resting electroencephalogram alpha power was recorded. Teachers rated social skills of FCG children who were placed into foster care before 20 mo of age as no different from NIG children, and both of these groups were higher than CAUG children and FCG children placed *after* 20 mo. Electroencephalogram alpha power at age 8 significantly moderated the relations between attachment security and social skills. These findings characterize institutionalized children's social skills in middle childhood within the context of a randomized intervention while highlighting the roles of both relational and biological factors in these developmental trajectories.

social behavior | neglect | early experience

The present study examined 8-y-old children who had a history of institutional rearing to better understand the impact of this early experience on social skill development in middle childhood. Specifically, we examined the timing of an intervention (placement into a foster care home), as well as attachment security with the primary caregiver at 42 mo and children's brain electrical activity in relation to teacher-rated social skills at 8 y of age.

Considerable research has been conducted examining the consequences of severe emotional and physical deprivation associated with institutional rearing across physical, cognitive, and social domains (e.g., 1–4). Recently, these findings have been augmented by demonstrations of abnormal brain structure and functioning following severe early deprivation (5–10). Across these studies, several factors appear to influence outcomes, for example, age of placement into an institution (11), timing of removal and placement in a family (2), and sex of the child (12).

Additional work has focused on social developmental outcomes following institutional rearing. Many studies have characterized children's attachment relationships formed with institutional (13, 14), adoptive (15), or foster (16, 17) caregivers. These studies have documented profound problems in the attachment relationships that young children form with caregivers following early deprivation. In addition, these children are reported to display abnormal social behavior toward adults (e.g., 18–20). Additional research has examined the social behavior of institutionalized children among their peers, including their social skills, close relationships, or friendships. Erol et al. (21) examined adolescents' self-reports of their social behavior in a sample of 11–18 y olds living in institutional care in Turkey and found that, compared with a community sample, institution-reared adolescents were reported by caregivers and teachers to have more social problems. A study from the English and Romanian Adoption study sample in the United Kingdom by Roy and colleagues (22) examined the social behavior of primary-school–aged children living in a residential care setting compared with children reared in a foster family. Using caregiver reports, they found that 20% of the institutionalized children, but none of the foster children, reported having few or no specific friendships. They concluded that lack of social relationships with peers was related to lack of a close relationship with a specific caregiver (e.g., a parent), as opposed to interactions with multiple caregivers who worked rotating shifts, although this was not tested explicitly.

Thus, it appears that children who have experienced early social deprivation show diminished social functioning across multiple studies in terms of their relationships and social interactions with caregivers, other adults, and peers. However, few studies have examined how variations in attachment relationships with caregivers may influence later social developmental consequences of early institutionalization (i.e., social deprivation). Also unknown is how these processes work in the context of an early intervention, such as placement in a foster care home, which likely influences the formation of attachment relationships, as well as subsequent social behavior with peers across time.

Much of the research on the effects of institutional rearing has focused on early childhood, but it is important to understand the influence of institutional rearing on children's social development in middle childhood. First, social behaviors in childhood set the stage for children's success at negotiating the increasing social demands and social changes that occur across the transition to adolescence. Social rejection or exclusion can lead to adolescents' involvement in delinquent or risk-taking behaviors (23). Indeed, Erol et al. (21) found that those institutionalized adolescents who reported fewer friends, poorer relationships with friends, and poor problem-solving skills also reported higher

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internalizing and externalizing problem behavior. Furthermore, difficulties with peer relationships in childhood have been linked to difficult adjustment in adulthood (24). Therefore, it is imperative to determine whether a foster care intervention, which places children in a family setting, can potentially remediate some of the negative social effects of previous institutional care and identify specific factors that play a role in this process. Second, adverse early experiences may compromise later emerging developmental processes that cannot be ascertained at very young ages, such as the profound effects of institutional rearing on executive functioning in middle childhood (25).

Researchers studying the effects of institutionalization have generally not included brain functioning in studies of children's social skills. However, research examining the direct effects of psychosocial deprivation on brain activity has identified significant effects upon glucose metabolism (5), functional MRI activity of specific brain regions (6), and EEG activity (7). In particular, EEG activity is thought to reflect attention and processing of sensory stimuli. Specifically, alpha is a dominant frequency band in the EEG, seen in adults at 8–13 Hz, and is associated with attention to a range of sensory stimuli. In typical community populations, the frequency location of the alpha band has been shown to *increase* with age, beginning around 4–6 Hz in the first half of the first year of life. Thus, low or absent alpha power during rest has been associated with developmental abnormalities, whereas patterns of higher alpha power are thought to represent cortical maturity. Previous analyses from the Bucharest Early Intervention Project (BEIP) revealed that young children who were living in institutions displayed significantly lower EEG alpha power compared with age-matched community controls at a baseline assessment. This was hypothesized to reflect delayed cortical maturation that has been linked in other studies to lower socioeconomic status and increases in inattention and impulsivity (8). Indeed, previous work from the BEIP found that the pattern of low alpha EEG activity obtained at 6–30 mo served as a mediator between institutionalization and 54-mo symptoms of Attention Deficit Hyperactivity Disorder (ADHD), a psychiatric disorder involving both signs of inattention and hyperactivity (9). In addition, another recent BEIP analysis found that children in the Foster Care Group (FCG), especially if placed at a younger age (before 24 mo), displayed recovery of EEG alpha power at 8 y of age compared with those in the Care As Usual Group (CAUG) (26). What has not been examined is how such variation in EEG activity (e.g., alpha power) among children who have experienced severe social deprivation early in life is associated with the development of social skills and the effects of early attachment experiences on those social skills. It is possible that security of attachment only exerts an effect on later social skills if it acts to alter the neurocircuitry affected by previous institutionalization early in development. Thus, given previous relations to developmental outcomes as well as the intervention and timing effects that have been reported, EEG power in the alpha band at age 8 was examined in the current study. The present study examined whether such relational (i.e., attachment security) and biological (i.e., alpha power) factors operate together to influence teacher-rated social skills in middle childhood.

In the present study, we compared the social behavior of three groups of children at age 8. At this age, children are typically beginning to expand their social skills set and increasingly value interactions with peers and friendships, the majority of which occur in the school setting (27). In addition, this time frame provided an assessment point during which there were minimal expected transitions related to school (e.g., entry into formal schooling) or the study (e.g., placement into foster care). The first group comprised institutionalized children who at the outset of the study were randomly assigned to continue institutional care (CAUG); the second group comprised previously institutionalized children who were randomly assigned at the outset of the study to foster care (FCG); and the third group comprised children from the Bucharest community who had never experienced institutional care [the Never-Institutionalized Group (NIG)]. Overall, the present study had three main goals: (*i*) to compare the social skills of children randomized to foster care intervention and children randomized to continued institutional care with those of children from the community; (*ii*) to determine whether the timing of the foster care intervention influenced social skills; and (*iii*) to examine the influence of early attachment experiences and the moderating influence of EEG alpha power at 8 y on social skills in middle childhood for children who had experienced any early institutionalization (the FCG and the CAUG).

Results

Intent-to-Treat and Timing Effects. NIG children were rated as significantly higher on social skills than both the FCG and CAUG children by teachers ($P < 0.01$). For FCG children, the earlier they were placed in foster care, the higher the teacher rated their social skills at age 8 ($r = -0.40$, $P = 0.004$). To further examine this significant relation, dichotomous grouping variables were created for foster care entry cutoffs at 18, 20, 22, and 24 mo of age. Children in each group were compared on the basis of their teacher-rated social skills using a series of ANOVAs. Children placed into foster care *before* 20 mo of age were rated significantly higher in social skills than children placed *after* 20 mo of age. A univariate ANOVA comparing the CAUG and FCG children placed *before* 20 mo, FCG children placed *after* 20 mo, and NIG children revealed that FCG children placed *before* 20 mo were rated by teachers as significantly higher than CAUG children and FCG children placed *after* 20 mo, but no differently from NIG children (Fig. 1). See *SI Text* for more information regarding ANOVA analysis and output.

Prediction of Social Skills from Attachment Security and EEG Activity. The prediction of children's teacher-rated social skills at 8 y of age from their attachment security at 42 mo of age and the moderating influence of EEG activity was examined for the institutionalized groups (CAUG and FCG) using hierarchical linear regression analysis (see *SI Text* for further details). Alpha power at 8 y ($\beta = 0.27$, $t = 2.48$, $P = 0.01$) emerged as a significant main effect. However, this relation was qualified by a significant interaction ($\beta = 0.23$, $t = 2.15$, $P = 0.03$) showing that alpha power significantly moderated the relation between attachment security and social skills. This interaction effect was

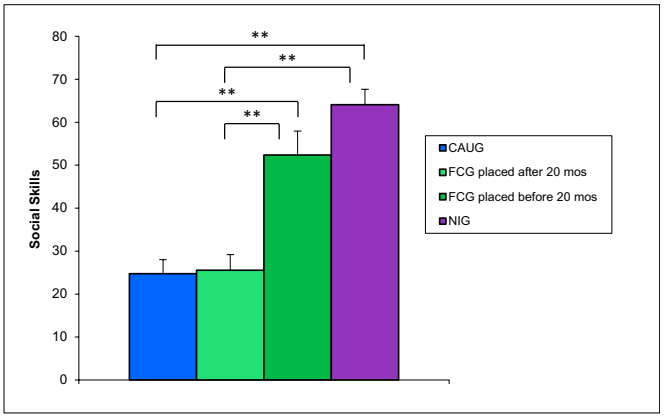

Fig. 1. Teacher-rated mean scores on social skills for CAUG children ($n = 44$), FCG children placed after 20 mo of age ($n = 35$), FCG children placed before 20 mo of age ($n = 15$), and NIG children ($n = 36$). Results show group differences at $^{**}P < 0.001$.

further probed under the guidelines of Aiken and West (28) (details can be found in *SI Text*). For children with higher alpha power (+1 SD), greater attachment security significantly predicted better social skills ($\beta = 0.30$, $t = 2.26$, $P = 0.026$), whereas for children with lower alpha power (−1 SD) there was no relation between attachment security and later social skills ($\beta = -0.10$, $t = -0.70$, $P = 0.48$) (Fig. 2). See *SI Text* for more details regarding regression model analysis and output.

Discussion

The present study sought to examine the social skills during middle childhood of children in the BEIP who had experienced early institutional care. Using a conservative intent-to-treat approach, we examined social skills as reported by teachers in three groups of children: children who were randomly assigned to continued institutional care (CAUG), children who were randomly assigned to foster care (FCG), and children from a community sample (NIG). Results showed that there was a significant effect of age at placement in foster care in that children who were placed *before* 20 mo of age not only were rated as more socially skilled by teachers than those placed later, but also were rated as no different from children from the NIG and significantly better in social skills than children from the CAUG. These results highlight the value of early intervention on the development of institutionalized children's social skills. However, FCG children placed *after* 20 mo of age were not rated as highly as the NIG, indicating increased vulnerability resulting from potential limitations in the degree of recovery that was possible using later placement in families as an intervention.

We also examined the social skills of children in our institutionalized sample as a function of both relational and biological factors. We found that children's EEG alpha power emerged as a significant moderator of the relation between attachment security and social skills in the school setting. This pattern of EEG (high alpha) among the foster care children at age 8 for those who were removed from institutions before 24 mo of age was similar to that of typical age-matched community controls (10). Alpha activity is associated with attention and processing of sensory stimuli, and this pattern of high EEG alpha reflects a pattern of cortical maturity. An opposite pattern was found among the BEIP institutionalized sample before randomization (8) and may reflect a delay in cortical maturation. In fact, we previously demonstrated that low alpha power mediated the relations between institutionalization and expression of ADHD symptoms at 54 mo in the BEIP sample. Children with a history of institutionalization and lower alpha power at baseline were more likely to exhibit ADHD symptoms at 54 mo compared with institutionalized children with higher alpha power (9). It also is important to note that, by 8 y of age, among the BEIP children in the FCG and those placed before 24 mo of age, alpha power was at a level indistinguishable from the NIG, whereas for children placed in the FCG after 24 mo and children randomized to the CAUG, alpha power remained low at 8 y of age (10).

Thus, differences in alpha power in middle childhood may reflect perturbed neural development as a function of adverse early life experiences and a violation of the expectable environment for young children across childhood. Functionally, lower alpha power may influence attention- and sensory-processing abilities. When considering social skills, the positive effects of a strong attachment relationship during early childhood are seen in those children whose EEG power is more mature and age appropriate. Indeed, the SSRS measures a child's level of skill at negotiating a variety of social situations and contexts, including initiating contact with new peers, solving disputes, managing peer pressure, and regulating their own emotions. In addition, the SSRS assesses a child's ability to act in ways that do not negatively impact the larger peer group (e.g., uses time wisely, attends to teachers requests, appropriately questions rules). Success in this broad range of skills seems to reflect both cognitive skill and early social experiences with a caregiver.

Alpha activity at baseline was also found to mediate signs of ADHD at 54 mo in our sample (9). Specifically, children with a history of institutionalization who showed lower alpha power were more likely to exhibit signs of ADHD at 54 mo of age. Thus, just as the early experience of being institutionalized influenced ADHD symptomatology through effects on EEG alpha power at baseline (9), the experience of forming a more secure attachment relationship combined with a recovery of EEG alpha power by age 8 influenced social skill development in the current analysis. Although this causal link cannot be examined within the bounds of the current analysis, clearly, the trajectories of brain development are influenced by social experience and appear to have important effects upon teacher-rated social skills in middle childhood.

The present study provides a multilevel, multimethod assessment of the effects of early intervention, observed attachment security, and brain activity on institutionalized children's social skills, as rated by teachers during middle childhood. These results contribute to our understanding of the social skills of children who have experienced severe social deprivation associated with early institutional rearing. Using a conservative intent-to-treat approach, it also highlights the positive influence of a foster care intervention on the social development of children who have experienced deprivation. We provide data that show the role of EEG alpha power on the relations between attachment security and subsequent social skills. These data highlight the need for researchers to understand a broad range of mechanisms that act to remediate the negative effects of institutionalization on children's social development during middle childhood, so that children are adequately prepared to meet the increasing social demands of adolescence.

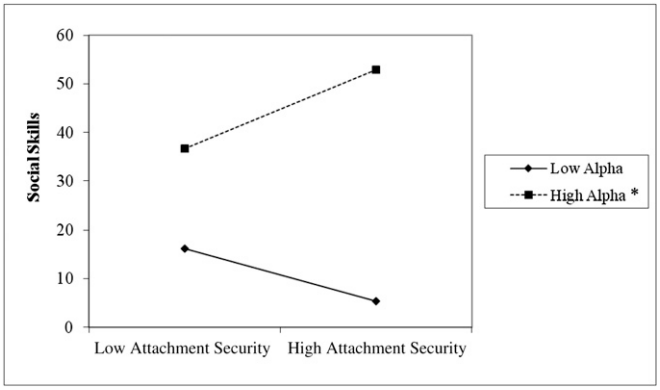

Fig. 2. Moderation of the relation between attachment security at 42 mo of age and social skills at 8 y of age by alpha power at 8 y of age. Results show significant relation only when alpha is high (*$P < 0.05$).

Methods

Participants. Participants were 52 FCG children, 44 CAUG children, and 97 NIG children who were part of the BEIP and whose teachers provided a report of their social behavior when they were 8 y of age ($M = 8.58$, SD = 0.34, range: 7.44–9.39). For a complete description of the sample, see *SI Text*.

Measures and Procedures. ***Attachment.*** Attachment security was assessed via observations when children were 42 mo of age in the BEIP laboratory using the preschool version of the Strange Situation Procedure (29). As all children had been randomized to the intervention groups by this assessment point, CAUG children were seen with their favorite caregiver and FCG children were seen with their foster mother. A complete presentation of these data may be found in ref. 16. For the purposes of the present analyses, a continuous rating of security was used, whereby coders assigned a security score to

each child using a scale from 1 to 9, with 1 equalling "no security evident" and 9 equalling "most secure." Reliability was excellent (r = 0.87).

EEG power. Children's brain electrical activity (EEG) was acquired at 8 y of age. The details of the acquisition and group comparison analyses have been reported elsewhere (10). Children sat quietly for 6 min alternating eyes open and eyes closed while 20 channels of EEG were collected. These data were subsequently preprocessed, and periods of eye movement and motor artifact were identified and deleted. The processed EEG was then submitted to a discrete Fourier analysis, and amplitude in individual frequency bins from 1 to 20 was computed. See *SI Text* for more detail regarding EEG data collection and analysis. For the purposes of the present analyses, EEG power in the alpha band at 8 y was created by computing an unweighted average of alpha power across hemisphere and brain region.

Social skills. Children's teachers were asked to report on children's social skills using the SSRS (27). The raw and percentile scores were used in the current analysis. See *SI Text* for more information.

Data Analytic Approach. Data analysis in the current article used an intent-to-treat design. Children randomized to one of the two treatment arms of the Bucharest Early Intervention Project (FCG or CAUG) were considered to have remained in those treatments across the time period of the study. Group differences on social skills were analyzed using a series of ANOVAs where these groups were examined in relation to each other and the NIG. Regression analyses examining attachment security and EEG alpha power in relation to social skills were conducted using the FCG and CAUG combined. More detail on the specific analyses is provided in *SI Text*.

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