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Motor Outcomes in Children Exposed to Early Psychosocial Deprivation

April R. Levin, M.D.^{1,2}, Charles H. Zeanah Jr., M.D.³, Nathan A. Fox, Ph.D.⁴, and Charles A. Nelson, Ph.D.^{2,5}

¹Department of Neurology, Boston Children's Hospital/Harvard Medical School

²Laboratories of Cognitive Neuroscience, Boston Children's Hospital/Harvard Medical School

³Department of Psychiatry and Behavioral Sciences, Tulane University School of Medicine

⁴Department of Human Development, University of Maryland, College Park

⁵Harvard Center on the Developing Child

Abstract

Objectives—To determine the effect of psychosocial deprivation early in life on motor development and assess the impact of a foster care intervention on improving motor development.

Study design—In a randomized controlled trial, children living in Romanian institutions were randomly assigned to care as usual in the institution, or placed in family centered foster care as part of the Bucharest Early Intervention Project (BEIP). The average age of placement into foster care was 23 months. At 8 years of age, the Bruininks-Oseretsky 2nd edition, short form (BOT2-SF) assessed the motor proficiency of children in both groups, as well as a never-institutionalized group from the Romanian community.

Results—Children in the never-institutionalized group did significantly better on the BOT2-SF than children who had ever been institutionalized. ($p < .001$). There was no significant difference in performance between children in the care as usual group and foster care group. This finding also held true for all individual items on the BOT2-SF, except sit-ups. Regression analyses revealed that the between-group and within-group differences in BOT2-SF scores were largely mediated by IQ.

Conclusions—Early deprivation had a negative effect on motor development which was not resolved by placement in foster care. This effect was predominantly mediated by IQ. This study

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Correspondence: April R. Levin, M.D., Boston Children's Hospital, 300 Longwood Ave, Fegan 11, Boston, MA 02115, Phone: 617-355-2711, Fax: 617-730-0288, April.Levin@childrens.harvard.edu.

Reprint Requests: April R. Levin, M.D.

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highlights the importance of monitoring for and addressing motor delays in children with a history of institutionalization, particularly those children with low IQ.

Keywords

institutional care; foster care; development; Bruininks-Oseretsky; BEIP

During sensitive periods of development, neuronal circuits are thought to be more plastic than at other times and therefore most apt to be altered by the types of experiences to which the child is exposed.¹ Early severe deprivation, as occurs in the case of young children placed in institutions, leads to missed opportunities to modify neuronal circuits in preparation for future learning in multiple domains; placement in a more enriched setting, such as family care, provides an opportunity to rescue development in these domains if done within an appropriate timeframe.^{2–13}

Previously published data on motor development in populations of institutionalized and previously institutionalized children found that motor development is affected significantly by institutionalization. In an orphanage in Sudan, developmental quotient was <70 for coordination development in 20% of children living in orphanages at 2 months of age; this rose to 57.1% at 18 months.¹⁷ Among children living in Romanian institutions who did not have overt neurological disabilities, the mean percentile rank was <6% for both gross motor and fine motor skills among children tested at a mean of 2.4–2.6 years of age.¹⁸ These findings persist after adoption; in one study of international adoptees, 33% of children had gross motor delays and 40% had fine motor delays.¹⁹ The environment and cultural context of caregiving prior to adoption can alter these numbers greatly; in a study of children adopted specifically from Eastern Europe and the former Soviet Union at a median age of 26 months (range 2.5 months to 9 years), 70% had gross motor delays and 82% had fine motor delays,²⁰ and in a study of previously institutionalized children adopted from Guatemala the majority of children were doing well developmentally.²¹ The timing of institutionalization seems to have an important effect as well. In children adopted from Romania, those who had spent less than 6 months in an institution had significantly better motor skills than those who had spent more than 6 months in an institution.²² Similarly, longer institutionalization histories were associated with significantly lower scores than shorter institutionalization histories on vestibular-proprioceptive, visual, and praxis areas of the Sensory Integration and Praxis Tests,²³ as well as balance.²⁴ Placement in a family setting has thus far been found to improve outcomes only minimally; psychomotor development scores in adopted children were generally found to be higher 6 months after adoption than at the time of adoption,²⁵ postinstitutionalized children have delays in balance and bilateral coordination compared with never institutionalized children which placement in a family setting does not adequately remediate.²⁴ However, a selection bias of children chosen for adoption was inherent in these studies because physically and psychologically healthier children may be more likely to be adopted into families. The Bucharest Early Intervention Project (BEIP), a randomized controlled trial of institutionalization versus foster care, provides the opportunity to examine motor development in institutionalized Romanian children randomly assigned to continued institutional care or to a foster care intervention.

The Bruininks-Oseretsky test of motor proficiency, 2nd edition has been found to be useful for differentiating individuals with motor impairment from those with no motor impairment.²⁶ Use of standard scores for motor composites has been recommended for comparing motor performance between examinees.^{26,27} The short form of this test (BOT2-SF) has been found to have a positive predictive value of 100% and a negative predictive value of 72.5% for diagnosing motor impairment.²⁸ The objectives of the current study are to: (1) investigate the prevalence of abnormal motor development in children with a history of early institutional care, (2) describe the specific motor delays encountered in children with a history of early institutional care, (3) evaluate the efficacy of a foster care intervention compared with continued institutional care in improving motor development, and (4) assess the association between motor and cognitive outcomes in children with a history of institutional care.

Methods

Participants in this study were children enrolled in the BEIP. Full historical background, design, and ethical considerations of this study are described elsewhere.^{31–33} Institutional Review Boards at Boston Children's Hospital, the University of Maryland, and Tulane University approved the study. The Institute for Maternal and Child Health and the local Commissions for Child Protection in Romania also approved the protocols. Informed consent was obtained from biological parents, the Commission for Child Protection, or both for all children in the study. In a group of 187 children institutionalized in Bucharest, Romania, children with genetic syndromes, fetal alcohol syndrome, or microcephaly as assessed by physical exam were excluded. The remaining 136 children constituted the ever institutionalized group. Of these, half were randomly assigned to a foster care group and the other half were assigned to continued care as usual in the institution. A never-institutionalized community comparison group was matched to the other groups by child age and sex.³¹ BOT2-SF was performed on children from each group (Figure). Demographics and birth data for each group are provided in Table I.

In the foster care group, the average age of foster care placement was 23 months (range 8–33 months). The foster care intervention was designed to represent the home experience of a never-institutionalized child, and thus to provide a replicable, affordable, and culturally relevant alternative to institutionalization. There were 2.5 other people in the foster households, on average. Using the Observational Record of the Caregiving Environment, we have previously demonstrated that the quality of caregiving in foster care was indistinguishable from the quality of caregiving in the families of never-institutionalized children from the community, and was significantly better than that in institutions.³³ In the care as usual group, a policy of noninterference was implemented for ethical reasons, such that children who later had the opportunity to be placed in foster care or return to other family environments were not prevented from doing so.³² Therefore, at the time of this study, 11 of the children randomized to the care as usual group remained in institutions. Children in the foster care group were not allowed to return to institutions, but were allowed to transition to non-BEIP versions of family-centered care in some situations. All analyses were initially performed following an intent-to-treat model, with children considered within their original assigned group. Thus, our findings represent a conservative estimate of the

response to intervention. Follow-up analyses were performed based on the children's living situation at the time of BOT2-SF testing, and percent of life spent in an institution.

The BOT2-SF was performed on study subjects at their 8-year-old follow-up visit. The BOT2-SF measures a child's proficiency in four motor-area composites: Fine manual control, manual coordination, body coordination, and strength and agility. Fine manual control includes subtests of fine motor precision and fine motor integration. Manual coordination includes subtests of manual dexterity and upper-limb coordination. Body coordination includes subtests of bilateral coordination and balance. Strength and agility includes subtests of running speed and agility and strength. Total point scores on the BOT2-SF were normalized by age and sex to calculate the standard score for each subject.²⁶ Percentile scores were used only when calculating the relationship between motor outcome and IQ, to allow comparison with other studies. Point scores were used when comparing results for individual items.

IQ was measured using the Wechsler Intelligence Scale for Children (WISC-IV; Wechsler, 2003).³

Among children who completed the BOT2-SF, birth weight was significantly lower in the ever institutionalized group compared with the never-institutionalized group, and ethnicity was significantly different between the ever institutionalized group and never-institutionalized group children. Gestational age was also significantly different between care as usual group and foster care group children (Table I).

All data were analyzed using IBM SPSS Statistics, version 19.

Results

Prior Institutionalization

Initial analyses examined whether children with a history of institutional care (ever institutionalized group) performed differently on total measures of motor function than children without a history of institutional care (never-institutionalized group). Independent sample *t*-tests revealed that children in the never-institutionalized group performed significantly better on the BOT2-SF than children in the ever institutionalized group ($p < .001$). Children in the never-institutionalized group had an average BOT2-SF score equivalent to that expected for an 8-year-old child. Children in the ever institutionalized group had an average BOT2-SF score equivalent to that expected for a 6.5-year-old child (Table II). Within the ever institutionalized group, simple linear regression demonstrated that BOT2-SF scores did not significantly correlate with age in months at the time of initial institutionalization ($R^2 = .001$, $B = .060$, Standard Error = .232, $\beta = .026$), or with the total percent of a child's life spent in an institution by 8 years ($R^2 = .005$, $B = -.026$, Standard Error = .038, $\beta = -.071$).

Foster Care Intervention

Further analyses assessed the effect of the foster care intervention among children with a history of institutionalization. Independent sample *t*-tests revealed no significant differences

on the total BOT2-SF outcomes between the care as usual group and foster care group ($p = .314$) (Table II). Repeating this analysis excluding children who had previously received physical therapy (1 from the care as usual group, 5 from the foster care group) again revealed no significant differences between groups.

Individual Items

To examine whether specific motor skills accounted for the lower BOT2-SF scores in the institutionalized groups, point scores for individual items were compared between groups. The ever institutionalized group had significantly lower scores than the never-institutionalized group on all items on the BOT2-SF except for sit-ups (Table II). Independent sample t -tests revealed no significant differences in any item scores when comparing care as usual group with foster care group (Table II).

Demographics and Birth History

After controlling for demographics and birth history by regression, history of institutionalization was still a significant predictor of BOT2-SF score (Table III; available at www.jpeds.com). Among the ever institutionalized group, a regression model including demographics, birth history, and randomization group (care as usual group or foster care group) found that none of the variables in the model reached significance (Table III).

Living Situation at Age 8 Years

All of the results described above have followed an intent-to-treat model, with each analysis including the children in their originally assigned group. Since the study began, however, many children in the care as usual group have moved to foster care, and some children in the foster care group have moved to non-BEIP family-centered living situations. At the age of 8 years, of the children for whom we have BOT2-SF data in the care as usual group, 11 children remain institutionalized. Children currently living in BEIP foster care (foster care group, $n = 31$) were compared with children currently living in government foster care (care as usual group, $n = 16$; foster care group, $n = 5$), children reintegrated with their biological families (care as usual group, $n = 16$; foster care group, $n = 11$), and children currently living in an institution (care as usual group, $n = 11$). Among ever-institutionalized children, ANOVA reveals no significant between-group difference in BOT2-SF score between children living in BEIP foster care, government foster care, biological families, or an institution at 8 years of age ($F(3,86) = 2.12, p = .104$). Within the care as usual group, independent sample t -tests reveal no significant difference in BOT2-SF score between those children who remained institutionalized at 8 years (Mean BOT2-SF score 43.64 (SD 13.71)) and those who had been placed in another setting (Mean BOT2-SF score 41.36 (SD 7.57)) ($p = .481$). Within the foster care group, independent sample t -tests did reveal a significant difference in BOT2-SF score between those children who remained in BEIP foster care at 8 years (Mean BOT2-SF score 46.13 (SD 10.50)) and those who had been transferred to a different non-institutional setting (Mean BOT2-SF score 40.00 (SD 5.15)) ($p = .008$).

Correlation with IQ

A regression model evaluating the correlation of group and full scale IQ scores with BOT2-SF scores accounted for 49.5% of the variation in the BOT2-SF scores (Table IV). Of note, in this model the contribution of group was no longer significant, suggesting that many of the between-group differences in BOT2-SF score are in fact accounted for by the between-group differences in IQ. When BOT2-SF standard scores are converted to percentile scores, the regression suggests that for every IQ point lower, about 1.016 percentile points are lost on the BOT2-SF. In a follow-up regression model evaluating the correlation of group and WISC-IV subtests with BOT2-SF score, these differences were accounted for predominantly by the perceptual reasoning and processing speed subtests (Table IV).

Discussion

These results expand upon previous findings of deficits in motor proficiency among school-age children with a history of early deprivation due to institutional care. Results from this study are consistent with prior studies in demonstrating decreased motor skills in children who have ever been institutionalized. This study demonstrates that placement in a foster care environment at an average age of 23 months does not result in any significant improvement in motor skills by 8 years of age.

Additionally, within the care as usual group, there were no significant differences in BOT2-SF score between children currently living in an institution at the time of testing and those living in another setting. Because there was not random assignment between these two groups, it is possible that children remaining in institutions at 8 years differ from children who have been taken into family settings since initial randomization. However, this finding suggests that early institutionalization, rather than placement at the time of evaluation, is more likely to determine motor outcomes in this age group. On the other hand, within the foster care group, children remaining in BEIP foster care had significantly higher BOT2-SF scores than children who transitioned to other non-institutional settings. This suggests that stability of placement is of key importance in improving motor proficiency. Taken together, these findings suggest that stable placement in a high-quality, family-based setting is associated with improved motor outcomes for children who are placed in a family setting. This pattern is similar to that seen in studies of Early Head Start outcomes in multiple domains when children are followed up in the 5th grade, in which the initial improvements with early interventions are sustained over time only when positive interventions are sustained over time as well.³⁴

Regression analyses revealed that motor findings are largely mediated by perceptual reasoning and processing speed subtests of IQ testing on the WISC-IV. Previous research has found lower levels of motor proficiency to be associated with lower full scale IQ.¹⁶ 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. The networks may be affected to different degrees depending on the nature of these experiences. In other words, aspects of both IQ and motor skills may act as a marker for the extent to which brain development in particular areas has been affected or preserved.

Although the cerebellum was traditionally thought to coordinate predominantly motor activities, more recent work has suggested that it also coordinates cognitive activities in both adults³⁵ and children.³⁶ The majority of the tests on the BOT2-SF (perhaps except sit-ups and push-ups) require significant motor coordination; of note, sit-ups were the only item on which children in the ever institutionalized group and never-institutionalized group showed no significant differences in score. One possibility, therefore, is that cerebellar development mediates both selected aspects of cognition and motor skills, and deprivation affects cerebellar development. Notably, children with a history of early psychosocial deprivation have smaller volume of the superior-posterior cerebellar lobes, and superior-posterior lobe volume mediates neuropsychological test performance differences between groups of postinstitutionalized versus typically developing children, with larger volumes yielding better outcomes on tests of memory and planning.³⁷ The superior-posterior lobes have also been found to have a somatotopic map which is activated particularly during complex movements.³⁸

Despite the potential importance of the cerebellum in explaining our findings, motor development, like cognition, is a complex phenomenon and is unlikely to be explained by one brain structure or circuit in isolation. Instead, various aspects of motor development are likely to involve different brain networks which likely have different sensitive periods. MRI data of children in the BEIP has demonstrated that previously institutionalized children have significantly smaller cortical gray matter volume than never institutionalized children; cortical white matter is significantly reduced in the care as usual group compared with the never-institutionalized group, with the foster care group falling in between the never-institutionalized group and care as usual group.³⁹ Future studies may benefit from examination of specific anatomically-correlated motor networks, by imaging or related techniques, to determine those that are primarily affected by early psychosocial deprivation and its timing.

Studies in this cohort have shown that although multiple areas of development are impaired among ever-institutionalized children, foster care placement leads to improvement in some areas (e.g. cognition,^{2,3} attachment,^{5,6,40} language⁷⁻⁹, depression, anxiety,^{10,12} stereotypies,¹¹ and growth⁴¹) but not in other areas (e.g., memory, executive function,¹³ attention deficit hyperactivity disorder and disruptive behavior,^{10,12} as well as motor function based on the results of the current study). This observation leads to the question of what determines whether foster care will improve outcomes in a given realm of development. In this cohort, would specific motor enrichment in the foster environment have led to improved outcomes? Notably, removing the small number of children in the ever institutionalized group who received physical therapy from our analyses (more of whom were in the care as usual group than the foster care group) did not significantly alter the outcomes. Alternatively, if decreased motor skills in the ever institutionalized group are in fact a manifestation of psychosocial (rather than physical) deprivation, might these difficulties be better addressed in the future using psychosocial interventions?

Consider, for example, the possibility that earlier placement in foster care might help to prevent motor difficulties. A sensitive period can be a window of opportunity when a child receives adequate stimulation during this time; concurrently, it can be an opportunity for

disaster if deprivation occurs instead. One possibility, therefore, is that a sensitive period for development of motor skills, memory, and executive function occurs in the first few months of life, and deprivation during this period does not allow for adequate formation of the necessary neural circuitry that controls these functions. If this were the case, earlier placement in foster care than was done in this study may remedy development in these areas. Alternatively, ever-institutionalized children may have been exposed to a poorer quality gestational environment; prenatal history, nutrition, and exposures could all potentially contribute to the outcomes in the current study. Although birth weight was significantly different lower in ever-institutionalized than never-institutionalized groups, controlling for this difference by regression revealed that group placement still correlated with motor outcomes, and birth weight, gestational age, and Apgar score did not. However, it remains possible that prenatal factors not considered in the current study could contribute to motor outcomes.

Several limitations merit consideration when interpreting the results of this study. First, because children in this study were not randomized to foster care placement prior to 8 months of age, the potential effects of earlier placement on motor development cannot be assessed. Additionally, there may be contributions of the prenatal environment of the ever institutionalized group versus the never-institutionalized group that may be unaccounted for here. Because it would be ethically impossible to randomize children from birth into an ever institutionalized group versus never-institutionalized group, the possibility exists that children who are abandoned to institutions are somehow more biologically compromised than those not abandoned. Additionally, this study assesses motor ability at 8 years of age, but does not examine potential improvement in motor skills that may continue to occur as children continue to grow and develop over time. Further studies will be necessary to assess the effects of institutionalization and foster care placement on motor outcomes in older children and adults.

The societal and developmental implications of the BEIP and similar studies are broad. Partially based on initial findings in the BEIP, Romania now discourages institutionalization of abandoned children under two years of age,⁴² and concerted efforts have now been made to deinstitutionalize children (e.g., in 1989 there were more than 170,000 children living in institutions, and in 2010, there were approximately 22,000). This is a major shift in policy in Romania, where, during the reign of Nicolae Ceausescu family planning was controlled by the state with the goal of increasing the birth rate to ultimately increase the work force, and child abandonment soared as a result; simultaneously, the intentions and benefits of foster care had been considered highly suspicious in Romanian culture.^{32,33} By informing child placement decisions, these studies have the potential to improve outcomes for abandoned children not only in Romania but across the world, where UNICEF estimates greater than 143 million children are orphaned.⁴³

Although the current study expands upon the risks institutionalized children face, it also adds to the data suggesting that foster care placement by age 2 is not the entire solution to the worldwide problem of child abandonment. Further studies will be necessary to determine whether earlier placement in foster care can result in improvement in motor skills as well as memory and executive function, or whether factors during gestation may be affecting

outcomes and interventions need to be targeted during pregnancy toward parents at risk for child abandonment. Stability of placements over time should also be addressed. Additionally, opportunities to promote motor development in children with a history of early psychosocial deprivation, particularly those children known to have lower IQ, should be further explored. Those involved in their care should monitor for signs of motor delay, and consider the potential benefits of occupational therapy, physical therapy, involvement in recreational sports, and other interventions in these children.

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Abbreviations

BEIP	Bucharest Early Intervention Project
BOT2-SF	Bruininks-Oseretsky Test of Motor Proficiency, 2 nd edition, short form

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Figure 1.

Figure Group Status at 8 Years of Age

Distribution of subjects between groups at the time of randomization and at the time of BOT2-SF testing.

Demographics and Birth History by Group

Table 1

Child Characteristic	Ever Institutionalized (EIG)	Never Institutionalized (NIG)	Ever Institutionalized (EIG)	
			Care As Usual (CAUG)	Foster Care (FCG)
Sex				
Female, %	48.45	48.33	48.94	48
Male, %	51.55	51.67	51.06	52
Ethnicity				
Romanian, %	53*	92	47	58
Roma, Unknown, or Other, %	47*	8	53	42
Birth weight (grams)	2817 (642)*	3206 (417)	2923 (598)	2722 (672)
Gestational age (weeks)	37.1 (2.3)	37.7 (1.5)	37.6 (1.6)	36.5 (2.7) [†]
Apgar score	8.5 (1.3)	8.7 (1.1)	8.4 (1.6)	8.7 (1.0)

Numbers are expressed as percentages for categorical variables (sex, ethnicity). Numbers are expressed as mean (SD) for numerical variables (birth weight, gestational age, Apgar score).

* $p < .05$ ever institutionalized group vs. never-institutionalized group, independent sample t -test

[†] $p < .05$ foster care group vs. care as usual group, independent sample t -test

Table II

Total and Individual Item Scores by Group

Ever Institutionalized (EIG)				Ever Institutionalized (EIG)	
		Care As Usual (CAUG)	Foster Care (FCG)		
Total BOT2-SF Standard Score					
Subtest		Item	42.88 (9.27)*	51.92 (9.38)	43.80 (9.29)
Fine Motor Precision		Drawing Lines through Crooked Paths	6.04 (1.66)*	6.48 (1.11)	6.24 (1.56)0
		Folding Paper	4.56 (2.03)*	5.97 (1.58)	4.62 (2.27)
Fine Motor Integration		Copying a Square	4.30 (1.17)*	4.67 (0.68)	4.28 (1.14)0
		Copying a Star	2.63 (1.82)*	3.80 (1.36)	2.88 (1.83)
Manual Dexterity		Transferring Pennies	5.33 (1.59)*	6.18 (1.28)	5.62 (1.61)0
Bilateral Coordination		Jumping in Place - Same Sides Synchronized	2.41 (0.97)*	2.88 (0.45)	2.58 (0.88)0
		Tapping Feet and Fingers - Same Sides Synchronized	3.35 (0.76)*	3.67 (0.51)	3.24 (0.80)
Balance		Walking Forward on a Line	3.79 (0.58)*	3.95 (0.29)	3.82 (0.60)0
		Standing on One Leg on a Balance Beam - Eyes Open	2.58 (1.14)*	2.95 (1.16)	2.78 (1.06)0
Running Speed & Agility		One-Legged Stationary Hop	6.79 (1.53)*	7.42 (1.03)	6.70 (1.49)
Upper-Limb Coordination		Dropping and Catching a Ball - Both Hands	4.64 (0.84)*	4.87 (0.43)	4.54 (1.01)0
		Dribbling a Ball - Alternating Hands	4.37 (1.52)*	5.15 (1.49)	4.50 (1.66)0
Strength		Push-ups	3.59 (1.48)*	4.13 (1.38)	3.46 (1.53)
		Sit-ups	3.70 (1.39)0	3.92 (1.44)	3.76 (1.49)0

Numbers indicate standard scores for total, and point scores for individual items. All numbers are expressed as mean (SD).

* p .05 ever institutionalized group vs. never-institutionalized group, independent sample t -test

No values are significantly different when comparing foster care group vs. care as usual group by independent sample t -test

Table III
Multiple Regression of Demographic, Birth, and Group Variables on BOT2-SF Standard Score

	All Children (EIG and NIG)				Ever Institutionalized Children (CAUG and FCG)			
	B	Std. Error	Beta		B	Std. Error	Beta	
Male gender	-2.77	2.83	-0.13		2.58	4		0.13
Romanian Ethnicity	-0.2	3.29	-0.01		-0.37	3.86		-0.02
Birth Weight (grams)	0	0	0.01		0	0		-0.19
Gestational Age (weeks)	0.09	1.45	0.01		-0.3	1.71		-0.04
Apgar score	1.05	1.12	0.12		2.26	1.59		0.29
History of Institutionalization	-8.51	2.87	-0.39*					
Randomization to Foster Care					-0.58	4.04		-0.03

Among All Children, $R^2 = .218$,
* $p < .05$
Among Ever Institutionalized Children, $R^2 = .092$. None of the variables in this model reached significance ($p < .05$)

Table IV

Multiple Regression of Full Scale IQ and Group Variables on BOT2-SF Standard Score

Group and Full Scale IQ	B	Std. Error	Beta
Group (CAUG, FCG, or NIG)	−0.003	0.874	0
Full Scale IQ	0.372	0.037	.704*

Group and WISC-IV subtests	B	Std. Error	Beta
Group (CAUG, FCG, or NIG)	0.42	0.883	0.035
Verbal Comprehension	0.113	0.062	0.215
Perceptual Reasoning	0.182	0.06	.313*
Working Memory	0.001	0.058	0.002
Processing Speed	0.199	0.055	.264*

Group and Full Scale IQ: $R^2 = .495$, $*p < .05$ Group and WISC-IV Subtests: $R^2 = .481$, $*p < .05$