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Do the Effects of Early Severe Deprivation on Cognition Persist Into Early Adolescence? Findings From the English and Romanian Adoptees Study

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Cognitive outcomes at age 11 of 131 Romanian adoptees from institutions were compared with 50 U.K. adopted children. Key findings were of both continuity and change: (1) marked adverse effects persisted at age 11 for many of the children who were over 6 months on arrival; (2) there was some catch-up between ages 6 and 11 for the bottom 15%; (3) there was a decrease of 15 points for those over 6 months on arrival, but no differentiation within the 6 – 42-month range; (4) there was marked heterogeneity of outcome but this was not associated with the educational background of the adoptive families. The findings draw attention to the psychological as well as physical risks of institutional deprivation.

The question of the impact of early physical and social deprivation on psychological development remains an issue of both scientific and clinical interest. However, because of both practical and ethical obstacles, the majority of human studies have relied on either case reports (Koluchova, 1976; Skuse, 1984a, 1984b) or smaller scale case – control comparisons (Lien, Meyer, & Winick, 1977; Winick, Meyer, & Harris, 1975). They therefore lacked the statistical power or methodological sophistication to resolve issues definitively, or to examine underlying processes in any depth. The English and Romanian Adoptees (ERA) study was set up to address these shortcomings; it is a longitudinal investigation into the effects of early deprivation on psychological development. The ERA study, like a number of related studies (Ames, Fraser, & Burnaby 1997; Marcovitch, Cesarone, Roberts, & Swanson, 1995), takes advantage of a ''natural experiment'' created by the fall of the Ceauşescu regime in Romania at the end of the 1980s. At that time a relatively large number of children who had spent their early years living in the extremely deprived conditions of state institutions were adopted into the generally above average conditions existing in adoptive families in countries such as the U. K. and Canada. This unusual set of circumstances provided a unique opportunity to examine the effects of very extreme early deprivation on development in a relatively large group of children.

The possibility of enhancement in cognitive abilities following a radical improvement in environmental circumstances has been demonstrated in several studies over the years (Carlson & Earls, 1997; Dennis, 1973; Money, Annecillo, & Kelly, 1983; Skeels, 1966). The findings, however, are limited in several key respects. First there are uncertainties regarding the extent to which the initial deficits are derived from malnutrition or social adversity (see, e.g., Galler & Ramsey, 1985; Liu, Raine, Venables, Dalais, & Mednick, 2003) and whether the subsequent gains are derived from improved nutrition or improved psychosocial circumstances (Grantham-McGregor, Schofield, & Harris, 1983; Grantham-McGregor, Walker, & Chang, 2000; Pollitt, Gorman, Engle, Martorell, & Rivera, 1993). Second, the findings do not delineate the period of time over which

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cognitive gains take place following a radical change in environmental circumstances. Third, the evidence does not indicate the extent to which there might be limitations on cognitive recovery and, if there are, what they might be due to. Fourth, few of the studies have had adequate comparison groups.

The ERA study was designed and powered to address questions about the impact of the length and specific developmental timing of extreme deprivation in the first $3\frac{1}{2}$ years of life. Two aspects of the circumstances around the adoption of the Romanian children facilitated this aspect of the study. First, the children typically entered the institutions as very young babies. This pattern of early admission and the fact that the age of placement into adoptive families was determined to a considerable extent by the timing of the fall of the Ceauşescu regime meant that it is unlikely that child disability or other child characteristics determined institutional placement, or their age at adoption. Second, the fact that institutional deprivation was directly followed by placement into the adoptive family meant that the onset and offset of deprivation (and so also its duration) could be timed precisely. Reliable data about the reasons children in the ERA study were placed in institutions are not available, but factors such as severe poverty, social exclusion, and disadvantage are likely to have played a major role (Children's Health Care Collaborative Study Group, 1992).

The power of the study to detect the effects of the timing of deprivation was strengthened further by the use of a stratified sample with similar, relatively large-sized groups of children entering the U.K. and being placed with their adoptive families before the age of 6 months, between 6 and 24 months, and between 24 and 43 months. A comparison group comprised children born and adopted in the U.K. before the age of 6 months. Previous papers have reported outcomes across a range of intellectual, behavioral, and cognitive domains at ages 4 and 6 years (Castle et al., 1999; O'Connor et al., 2000; Rutter & the English and Romanian Adoptee Study [ERA], 1998; Rutter, O'Connor, & ERA, 2004). The current paper builds on these findings by reporting on cognitive performance at 11 years of age.

The pattern of results relating to cognitive outcomes at ages 4 and 6 in many ways confirmed the findings of previous case reports and smaller scale studies (Koluchova, 1976; Lien et al., 1977; Skuse, 1984a, 1984b; Winick et al., 1975). First, the findings provided the strongest evidence to date for the negative effect of early deprivation on cognition, with the Romanian children on average having a General Cognitive Index (GCI) substantially lower than that of the within-U.K. adoptees (O'Connor et al., 2000). Second, there was a significant "dose–response" association between the age at which the child joined the household and cognitive performance at 6 years. Children arriving before the age of 6 months displayed a very similar profile to the within-U.K. adoptees. Children aged between 6 and 24 months at placement had somewhat lower scores and those over 24 months were particularly impaired. A comparison of children at ages 4 and 6 who had spent comparable lengths of time in the adoptive home but different periods in the institutions confirmed that this effect was due to duration of deprivation per se, rather than the time in the adopted home (O'Connor et al., 2000). Third, this significant effect of age on arrival was independent of the (small, but significant) effects of other factors, such as low body weight, small head circumference, and developmental delay at entry into the U.K. This suggested that the effects of early institutional care on cognition were not completely mediated by physical deprivation and that psychological deprivation is likely to have played an important role. Fourth, there was a considerable range of cognitive scores for all the children at the 4- and 6-year-old assessments (according to age on arrival), with some children, even in the late adopted group, doing extremely well while others were still impaired. Given the widespread and severe impairment witnessed at entry, this finding highlighted the considerable resilience shown by many of the Romanian adoptees, with a majority of children showing significant levels of catch-up by the time of their fourth or sixth birthday (O'Connor et al., 2000; Rutter & ERA, 1998).

This catch-up had two interesting characteristics. First, a comparison of outcomes at ages 4 and 6 years for children aged less than 24 months on arrival suggested that catch-up seemed to be largely complete by the age of 4 with little evidence of any further gains between 4 and 6 years (O'Connor et al., 2000). The children who were over the age of 24 months on arrival had only been previously studied at the age of 6, so it was not known whether there would be any further gains in their cognitive scores. Second, where there was catch-up between ages 4 and 6, this was particularly apparent among the most impaired children at age 4 (O'Connor et al., 2000).

In this paper we explore these issues further by examining the links between duration and timing of deprivation and IQ scores as measured on the WISC III^{uk} when the children were 11 years of age and compare these findings with cognitive findings at age 6. The lack of additional catch-up between the

4- and 6-year-old assessments in the early adopted groups (<24 months on arrival) (O'Connor et al., 2000) might lead us to predict that no further amelioration of the effects of deprivation would be observed between 6 and 11 years. It is not that intellectual gains following the removal of early adversities cannot occur. Duyme, Dumaret, and Tomkiewicz (1999), in their study of late adopted children removed from the care of their parents because of abuse or neglect, clearly showed that there were important gains following adoption and, moreover, that the degree of gain was systematically associated with the educational level of the adoptive home. Rather, the possible prediction of no further intellectual gain between ages 6 and 11 derives from the earlier findings in our sample and the implications from the 6-year-old follow-up pattern that some form of biological programming had occurred as a result of the profound institutional deprivation (Rutter et al., 2004).

Nevertheless, there are a number of reasons as to why there might be more catch-up than the 6-year-old findings implied. First, the more extended experience of school between 6 and 11 years might provide an additional protective influence over and above that associated with family life and the limited educational exposure before the age of 6 years. It could be expected that the effect of school would be demonstrated most clearly in relation to catch-up in the cognitive domain (Cahan & Cohen, 1989; Morrison, Smith, & Dow-Ehrensberger 1995). It is unclear whether these school effects would operate across all levels of deprivation and be related to those elements of cognitive deficit demonstrated at the 6-year-old follow-up to be specifically and independently associated with physical factors, such as weight and head circumference (O'Connor et al., 2000; Rutter et al., 2004). It may be that such deficits might be less responsive to the protective influence of educational experience.

Second, although the developmental catch-up may have been complete for the early adopted groups at age 6, this is less likely to have been the case for the children adopted later, who by the age of 6 had experienced a more protracted period of deprivation, but a shorter period of time in their adoptive home. It is possible that whereas, for the early adopted groups, 4–6 years was an adequate period of time for catch-up to be complete, later adopted children, who experienced more prolonged severe deprivation, might require an equivalent or longer period of positive rearing in the adoptive home to counteract the early effects of deprivation. In this case one would expect an uneven catch-up at 11 years, with the later adopted group's IQ scores improving between ages 6 and 11, and with those of the early adopted groups staying similar to those at age 6 years. Because this late adopted group was the most deprived at 6 years of age, it needed to be determined whether this differential catch-up, if it occurred at all, might be a consequence of severity of impairment rather than time in institutions.

There are a number of factors, other than length of deprivation, that might influence cognitive outcomes in children who demonstrate cognitive impairment following the experience of early institutional deprivation: factors that either constrain or promote the potential for long-term cognitive catch-up. Prenatal risk and postnatal nutritional effects might be important. Because the children were likely to have been admitted to institutions because of family poverty, it is possible that there were risks associated with either poor nutrition during the period in the womb or toxic effects associated with high maternal alcohol consumption during the pregnancy, and these might constrain the extent to which catch-up can occur in any individual. However, the poor quality of the Romanian records meant that there was no possibility of quantification of these risks. Nonetheless, such effects are unlikely because, in the absence of other risks, the fetus is relatively protected against prenatal subnutrition, and cognitive sequelae would be expected to be minor (Stein, Susser, Saenger, & Marolla 1972). On the other hand, there are some effects on birth weight (Bhargava, 2000). Under favorable circumstances, there may be catch-up growth in infancy following intrauterine growth retardation (Fernandez-Carrocera et al., 2003). Prenatal alcohol exposure has much greater effects on cognition (Streissguth, Barr, Bookstein, Sampson, & Olson, 1999) but, again, the biological impact is likely to be indexed by the low birth weight. Accordingly it was necessary to determine whether birth weight was associated with cognitive outcome at age 11.

Postnatal malnutrition is known to have deleterious effects on cognitive development (Wachs, 1995), probably especially in the context of serious psychosocial adversity. There are parallel effects on head growth (Stoch, Smythe, Moodie, & Bradshaw, 1982) that are, in turn, associated with lower IQ performance (Ivanovic et al., 2004). The findings call for attention to head circumference as a predictor of cognitive performance. It should be appreciated, however, that if psychological (rather than nutritional) deprivation leads to cognitive impairment, this too is likely to involve impaired brain growth and, therefore, impaired head growth.

The postadoption environment may also influence cognitive outcomes for children experiencing cognitive impairment as a result of institutional deprivation. The removal from a depriving environment to an adoptive home often results in an improvement in cognitive outcomes, but the degree of improvement may vary from child to child according to the background of the adopters and the nature of the adoptive environment, as well as a result of underlying genetic and background factors (Capron & Duyme, 1989; Duyme, 1988; Duyme et al., 1999). Accordingly, we examined the extent to which variations in adoptive parents' education and cognitive ability were related to variations in cognitive outcome between the ages of 6 and 11. Adoption into more highly educated families with higher socioeconomic status might enhance the overall cognitive scores of adopted children (Duyme, 1988; Duyme et al., 1999) without changing the rank order of those scores that may be related to genetic and individual child factors (Duyme et al., 1999; Scarr & McCartney, 1984).

In this paper we therefore ask the following questions: do the effects of early deprivation persist into early adolescence; is there significant catch-up between the ages of 6 and 11 years for the children who experienced institutional care in Romania; is catch-up at age 11 (if it occurs) a function of age on arrival or severity of impairment at age 6; which factors (e.g., birth weight, subnutrition during the institutional period, adoptive family characteristics) affect the cognitive outcomes for those children who have experienced early institutional care and are at risk for cognitive impairment as a result?

Method

Participants

The Romanian sample was drawn from 324 children adopted into U.K. families between February 1990 and September 1992, who were processed through the Home Office and/or Department of Health. The initial sample comprised 165 children adopted from Romania before the age of 43 months, selected at random from within two age bands, stratified according to age at entry to the U.K. and gender; <6 months; $6-<24$ months; $24-42$ months. All the families of the children of ≥ 24 months were selected as there were fewer numbers in this age band. A comparison group consisting of a volunteer sample of within-U.K. adoptees, who had not experienced institutional deprivation and who had been placed before the age of 6 months ($n=52$), was recruited via local authority and voluntary adoption agencies. More girls than boys in the Romanian sample were adopted over the age of 24 months (62%) and there were more boys than girls in the within-U.K. sample (66%).

The sample available for the analysis in this study consisted of 128 of the 131 children seen at age 11 (61 boys and 70 girls) who were adopted from institutional care (3 children were so profoundly impared that they could not complete the WISC assessment) and 50 children (33 boys and 17 girls) who were adopted within the U.K., taken from an overall sample of 217 children studied. Twenty-one of the Romanian children (those who had not experienced institutional care) were excluded from the analyses reported here, along with 13 children who did not take part in the 11-year-old assessment (4 of these children had also not taken part in the 6-year-old assessment). The 9 children who participated at age 6 years, but declined to take part at age 11, did not differ from the main sample in terms of either age on arrival, $t(137)=0.59$, *ns*, or cognitive scores at age 6, $t(133)=-1.19$, *ns* There was some spread in the educational abilities of the adoptive parents (in the Romanian sample 47% of the parents both had a degree or professional qualification, and for 36% one had a degree; in the within-U.K. sample 36% both had a degree or professional qualification and for 50% one had a degree) (Rutter et al., 2004). The majority was childless, but 39% had their own children before adopting, and 34% of the sample described altruism as a major motivating factor.

Measures

A broad-based assessment of intellectual and behavioral outcomes was made at both age 6 and age 11 years. The measures involved in the current analysis of cognitive outcomes were:

Duration of deprivation. Age on arrival and placement in the U.K. For the purpose of presenting key findings, the sample was stratified into three bands on the basis of age at entry and placement in the U.K. for the Romanian sample, these being <6 months ($n=42$), $6-<24$ months ($n=47$), and ≥ 24 months ($n=42$). For ease of presentation the within-U.K. group ($n=50$) was included in the category of age of arrival as a fourth group. The time that the child had spent in the institution was also dimensionalized according to the total months the child had spent in the institution. For the majority of children this was their entire life, but a small minority (8%) had spent more than half their lives with their family before they entered the institution and a further 37%

had spent the majority but not all their life in an institution.

Birth weight. Weight at birth was included as a continuous measure in standard deviation units.

Measures taken at time of entry into the U.K. Three deprivation-related indicators were taken from the time of arrival into the U.K.: weight on arrival as an index of malnutrition; head circumference on arrival as an approximate index of brain growth at arrival; and the Denver developmental quotient, an estimate of developmental status at the time of arrival.

Physical measures. Birth weight was known for 123 of the 128 children, for a few children it was not known as they had been abandoned. Weight on arrival was available for 128 children and head circumference measurements on arrival were available for 121 children and was used as an index of brain size. Cooke, Lucas, Yudkin, and Pryse-Davies' (1977) study of neonates showed a strong linear relationship between head circumference and postmortem brain weight, and Wickett, Vernon, and Lee's (2000) study of a volunteer sample of male adults using magnetic resonance imaging (MRI) showed a correlation of .66 between head circumference and brain volume. Moreover, head circumference showed a significant correlation with IQ, albeit not as strong as with brain volume. Wickett et al. (2000) concluded that: "overall the indication is quite clear that the size of the head predicts the size of the brain."

These measurements were taken from assessments carried out when the children arrived in the U.K. or as part of the entry clearance process that involved assessments in Romania and as part of the earlier stages of this study. Physical measures in the study were entered into the child health growth program to assess the measures relative to population norms (Boyce & Cole, 1993, based on Buckler, 1990). This metric provided a continuous standardized measure of physical development in terms of standard deviations above or below the norm for the age.

Developmental level. When the children were first studied at ages 4 and 6, parents were asked to provide a retrospective account of the child's developmental level at the time of arrival using the Denver Developmental Assessment (Frankenburg, van Doornick, Lidell, & Dick, 1986). This is a screening questionnaire that categorizes stages in a number of developmental domains: physical, fine, and gross motor skills, language development, and personal/social development. Scores were available for 121 children. The adoptive parents were asked to complete this assessment for all stages of development from birth however old the child was on arrival. From this scale a score was computed that indicated the degree of delay that the child was experiencing on arrival. Previous analyses performed on the entire sample demonstrated the validity of the retrospective Denver scales (Rutter & ERA, 1998).

Cognitive Outcomes.

Outcome at age 6 years: McCarthy Scales of Children's Abilities. The McCarthy Scales of Children's Abilities (General Cognitive Index: GCI) that were used to assess the children at age 6 were standardized on a nationwide U.S. sample in the early 1970s, and their validity and reliability tested by an assessment of stability over time, and correlations with scores from other ability were tests (McCarthy, 1972). The scale has not been renormed since 1972 and scores are therefore likely to be inflated relative to current norms (Flynn, 1987). The implications of this for the current study are considered below.

Outcome at age 11: Wechsler Intelligence Scale for Children. A short form of the Wechsler Intelligence Scale for Children (WISC 111^{uk}) was used to assess the children's cognitive abilities at age 11: this is the most commonly used standardized measure of the children's cognitive abilities and has established reliability (Wechsler, 1991). Four subscales of the WISC were used: two from the verbal scales—vocabulary and similarities; and two from the performance scales—block design and object assembly. These four subtests were selected to provide a good estimate of full-scale IQ (reliability coefficient = .94; Sattler, 1982). The four subscales were prorated to form a full-scale IQ score. Three children in the Romanian sample and one child in the within-U.K. sample were unable to complete the WISC assessment because of severe cognitive impairment, and they have been excluded from the analyses in this paper.

Background of adoptive parents. An approximate assessment was made of the mother's cognitive abilities using the NART (National Adult Reading Test; Nelson & Willison, 1994). This is a nonphonetic reading task of 50 words of increasing difficulty that has been shown to be highly correlated with IQ (Bird, Papadopoulou, Ricciardelli, Rossor, & Cipolotti, 2004). Details of the adoptive parents' educational qualifications were also gathered and classified on the basis of a three-point scale for fathers and mothers combined: low—neither mother nor father had a degree or professional qualification; medium—at least one parent had a degree or professional qualification; high—both parents had a university degree or professional qualification or above.

Procedure

The families were visited on two separate occasions at each assessment point. The first visit involved an intensive interview with the primary caregiver, and a set of behavioral and family relationship questionnaires. During the second visit the developmental assessment was carried out by research workers formally trained in cognitive testing, including the McCarthy scales of children's abilities at ages 4 and 6 and the WISC at age 11. Children older than 24 months on arrival were first seen at age 6, as they had passed their fourth birthday at the time of the start of the study.

The McCarthy scales of children's abilities have established reliability but, in contrast to the WISC, they have not been standardized for over 30 years (McCarthy, 1972). It is estimated that IQ scores since then have increased at approximately 0.31 points a year (Flynn, 1987). This means that standardized scores for the McCarthy scales of children's abilities and the WISC are not directly comparable and the McCarthy scales of children's abilities are likely to provide a considerably inflated estimate of performance relative to current norms. In order to adjust for this, it was necessary to derive comparable estimates of absolute IQ scores for the GCI scores at age 6 and WISC at age 11 to address directly the issue of catch-up between these assessments, that is, to assess if there had been a mean increase or decrease in scores over time. We observed that the McCarthy GCI scores for the within-U.K. group were 11 points higher at age 6 years than the WISC scores obtained at age 11 years. Using this difference as an index to correct for this likely artifactual increase in IQ assessments and provide a greater "equivalence" of the two sets of scores, the McCarthy GCI scores for each child were reduced by 11 points for all age bands before analysis. This adjustment does not affect the regression/correlational analyses, but it allows us to estimate the extent to which there may have been a mean increase or decrease in IQ; the limitations of this approach are considered in the discussion.

Results

Preliminary Analyses

Before the main analysis the possibility that bias in the selection of children for early and late adoption might lead to a confound between year of placement, age at placement, and impairment was investigated. Whereas there was a significant difference between the age of the children adopted in the first and second years (those adopted in the first year, mean age $= 13.15$ months; those adopted in the second year, mean age $= 18.74$), $t(129) = -2.81$, $p < .01$, there was no effect of year of adoption on cognitive outcomes, $t(129) = 0.74$, *ns*. Second, the associations between parental motivation to adopt, age at placement, and cognitive outcomes were assessed. Our sample was distinctive in that a quarter of the parents (25%) already had biological children of their own and over half (53%) of these said that altruism was their main motive for adopting (as compared with 20% among infertile couples). When infertility was the main motivating factor for adoption, there was a significant tendency for the children to be somewhat younger at the time of entry to the U.K., 14.4 months versus 20.3 months, $t(123) = 2.64$, $p < .01$. However, none of these three factors (presence of biological children, infertility, and altruism) was significantly associated with cognitive outcome. Within the group over 6 months of age at the time of arrival (the group for whom reliable estimates of development were available), there was no significant association between the children's age at the time of U.K. entry and the Denver developmental quotient, head circumference, or weight at arrival into the U.K. There was also no difference in standardized weight between those above and below 6 months of age on arrival. We conclude that it is very unlikely that there was any ap preciable selection bias that could affect cognitive outcomes.

Preliminary analyses were also carried out to check whether the child's age at time of arrival in the U.K. was a useful proxy for the length of deprivation experienced. In order to do this the association between the proportion of time before entry into the U.K. spent in institutions and cognitive outcomes at 11 years were examined. The 19 children who did not experience institutional care had a mean cognitive score of 96.84, $SD = 23.09$. This score was higher than that of those who had experienced institutional care (mean score $= 89.64$, $SD = 18.49$), but this difference was not significant, $t(148) = -1.54$, *ns*. Those who had spent less than half their life in an institution before entry into the U.K. ($n = 10$) had scores (mean $= 86.70$, $SD = 24.09$) that were lower, but not significantly lower than those who had spent all their life in an institution, $t(129) = 0.52$, *ns*. Those children who had spent more than half their life in an institution, but not their complete life ($n = 48$), also did not have cognitive scores (mean score $= 91.25$, $SD = 22.40$) that were different from those who spent their whole life in an institution (mean score $= 89.88$, $SD = 18.06$). As there were no differences between these groups, subsequent analyses use the age the children were on arrival and placement as a proxy of the period of time spent in deprivation.

Do the Effects of Early Severe Deprivation on Cognition Persist into Early Adolescence?

Table 1 presents the cognitive outcomes at ages 6 and 11 years for the within-U.K. adoptees and the three Romanian groups, according to age on arrival. A one-way analysis of variance (ANOVA) with GCI scores at age 6 as the dependent variable and age on arrival as the independent variable indicated marked and significant differences at age 6 between the groups according to age on arrival at this stage, $F(3, 172) = 20.89$, $p < .001$. Post hoc tests shown in Table 1 indicated three reliably different subgroups and suggested a linear dose–response relationship between age at placement and test performance: there were no significant differences between the within-U.K. adopted children and the Romanian children who were <6 months on arrival, $t(87) = 0.79$, *ns*. These two groups had significantly higher scores than the 6–24-month group, who in turn had significantly higher scores than the over 24-month group, $t(85) = 2.19$, $p < .05$.

A parallel analysis was then conducted for the prorated WISC scores collected at age 11. Again there was a significant effect of group (age on arrival), $F(3, 177) = 20.36$, $p < .001$. However, post hoc analyses revealed a different pattern with regard to the effect of age at placement. Again there was no difference between the within-U.K. adopted children and the Romanian children who were <6 months on arrival, $t(90) = 1.22$, *ns*. However, the only other significant difference was between these two groups and the 6 – <24-month and ≥ 24-month groups (see Table 1). Unlike at age 6, there was no significant difference between the two older age-at-arrival Romanian groups (6 – <24 months and ≥ 24 months on arrival), $t(87) = 0.40$, *ns*. This result reveals a different relationship at ages 6 and 11 between cognitive outcomes and age of placement in the group of children placed later than 6 months. This was confirmed by correlational analysis, with the highly significant correlation between age at entry and IQ shown at age 6 for this group of children, ($r(83) = -.32$, $p < .01$) disappearing by 11 years, ($r(83) = -.08$; *n.s*). This reduction was striking and significant, ($t(82) = 3.00$, $p < .001$) and confirmed that no additional risk was conferred as a function of age of entry into the U.K. within the group of children who were older than 6 months at placement. Although the variations of outcomes, expressed in the standard deviation of IQ scores, were somewhat smaller at age 11 than at age 6, these differences fell short of statistical significance except for the 6–24-month group (Levene's test of equality of variance, $F = 4.17$, $p < .05$).

Has There Been a Significant Degree of Catch-Up in Cognitive Abilities in the Romanian Group Between Ages 6 and 11 Years?

To test whether this change in pattern of outcome by length of deprivation was accompanied by a significant catch-up in cognitive abilities between ages 6 and 11, McCarthy GCI and prorated WISC IQ scores were entered as dependent variables into a two-way ANOVA with group (age on arrival) as the between-subjects variable and age at testing as the within-subjects variable. As expected from the previous analyses of the 6- and 11-year outcomes, there was a significant main effect of group (age on arrival), $F(2, 125) = 16.15$, $p < .001$. There was no effect of the age at which the cognitive scores were meaured, $F(1, 125) = 1.50$, *ns*. However, there was a sig-

Table 1
Cognitive Outcomes at Age 11 for the Within-U.K. and Romanian Adoptees by Age of Entry to the U.K.

	Within-U.K. sample ($n = 50$)		Romanian sample					
			<6 months ($n = 42$)		6–24 months ($n = 47$)		≥ 24 months ($n = 42$)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Adjusted McCarthy scores at age 6	105.08	17.93	102.04	18.42	86.34	17.66	76.92	22.44
WISC scores at age 11	105.06	15.69	100.86	17.85	85.70	13.72	82.83	18.98

Note. Significant contrasts: McCarthy GCI: (U.K. and <6 months vs. 6 – <24 months on arrival, $t(134) = 5.36$, $p < .001$); (U.K. and <6 months vs. ≥ 24 months on arrival, $t(85) = 2.19$, $p < .05$). WISC: (U.K. and <6 months vs. 6 – <24 months and ≥ 24 months on arrival, $t(179) = 7.66$, $p < .001$).

nificant interaction between group and age, $F(1, 125) = 3.88$, $p < .05$. Post hoc tests showed that this was accounted for by a significant increase in cognitive outcome for the late adopted group, $t(39) = -3.06$, $p < .01$, but not for any of the other groups, children <6 months on arrival, $t(39) = 0.92$, *ns*, and those 6 – <24 months, $t(33) = 0.73$, *ns*.

Was Catch-Up in Cognitive Level in the Oldest Group on Arrival a Function of Age on Arrival or the Severity of Impairment at Age 6?

Because the latest-placed adoptees were also the most cognitively impaired at age 6, these findings left it unclear whether the catch-up was primarily associated with age at arrival or severity of impairment. To disentangle this, the Romanian children were categorized into three groups according to their degree of cognitive impairment at age 6: those in the below 15th centile range, those in the 15th–30th centile range, and those above the 30th centile. Sixty-eight percent of the children in the below 15th centile group at age 6 years were 24 months or over on arrival, 30% were between 6 and <24 months, and 2% were under the age of 6 months on arrival in the U.K. Thirty-six percent of the children in the 15th–30th centile group were 24 months or over on arrival, 39% between 6 and <24 months, and 25% under 6 months on arrival. A two-way ANOVA with age at arrival grouping (<6 months, 6–<24 months, and ≥ 24 months) and severity of impairment as between subjects factors and degree of catch-up between ages 6 and 11 (IQ at 11 minus IQ at 6) as the dependent variable, indicated that there was a significant effect of degree of impairment on catch-up by age 11, $F(2, 118) = 92.18$, $p < .001$, but no effect of age on arrival, $F(2, 118) = 0.55$, *ns*. The catch-up was similar for those in the 6–<24 and ≥ 24 months age of entry groups (18 and 15 points, respectively) and no evidence of an interaction.

Table 2 shows the means and standard deviations for the IQ scores at 6 and 11 for the three groups with different degrees of impairment. Post hoc analyses indicated that the significant change had been for the most impaired group of children, whose IQ scores had increased significantly. There was no significant change for the children who had only mild impairment at age 6. Figure 1 illustrates this pattern of catch-up using a scatterplot of change from 6 to 11 years for each child as a function of their impairment grouping at 6 years. Four aspects of this figure are striking. First, there was a considerable degree of heterogeneity among individuals in terms of cognitive outcomes at both 6 and 11 years. Second, there was a high degree of continuity both at the level of the individual and in terms of their impairment category membership defined at 6 years, with the overwhelming majority of children maintaining their 6-year-old impairment status at 11. Third, there was a marked individual catch-up shown by many, if not most, children in the most impaired group. Fourth, despite this catch-up, many of these children remained within the most impaired group.

These analyses, suggesting a special role for the most impaired children in determining the correlation between outcome and deprivation at age 11 in the group of children who had experienced more than 6 months of institutional care, led us to reconsider the influence of extreme deprivation on these effects more generally at both ages 6 and 11. In order to do this we re-ran the correlations between age at entry and the 6- and 11-year-old outcomes after excluding the most impaired 15% of the Romanian sample experiencing more than 6 months deprivation. Most strikingly, this removed the correlation between these two factors at 6, from $r(83) = -.32$, $p < .01$ to $r(64) = -.06$, *ns*, reducing it to the level found for the complete sample at 11 years. The correlation at age 11 saw a similar shift in absolute terms but remained nonsignificant,

Table 2
Cognitive Scores at Ages 6 and 11 for Children Within the Bottom 15th Centile Group, the 15–30th Centile Group, and the Above 30th Centile Group in Terms of GCI Scores at 6 Years

	Bottom 15th centile ($n = 20$)		t	15–30th centile ($n = 23$)		t	Top 70th centile ($n = 80$)		t
	M	*SD*		*M*	*SD*		*M*	*SD*	
McCarthy scores at age six	58.03	10.71		76.65	1.98		101.32	14.07	
WISC scores at age 11	73.00	12.48	6.14***	80.00	12.25	1.26, *ns*	98.13	13.98	–2.28*

*$p < .05$, ***$p < .001$.

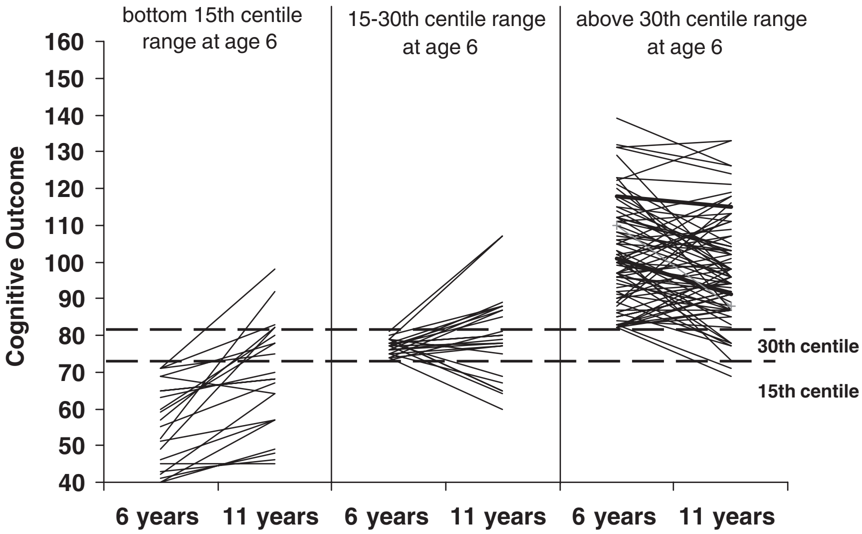

Figure 1. Scatterplot of change between 6 and 11 as a function of impairment at 6 years.

$r(64) = .19$, *ns*. This effect of degree of cognitive impairment in accounting for the lack of influence on IQ of the duration of institutional deprivation was not just a function of reduction in range. There was no comparable effect of excluding the top 15% of the distributions. These analyses reinforce the special role of extreme impairment in determining the negative effects of institutional deprivation found at age 6 years among the later placed children. In particular they suggest that these effects are carried almost entirely by the extreme impairment found in a subgroup of the very latest adopted children. In the light of this result we need to reconsider the previous reports claiming an essentially linear relationship between age of entry and outcome. It seems more likely that these effects are determined primarily by the rapid drop-off in IQ seen around the 6-month threshold combined with the disproportionate numbers of impaired children in the eldest group on arrival.

What Factors Affect Outcomes in Those Children At Risk for Cognitive Impairment Because of Institutional Deprivation?

In order to assess which factors affected outcome at 11 among those Romanian children at risk for cognitive impairment, we limited our analyses to the group who were older than 6 months at the time of their placement: the children at risk of cognitive impairment at 11. In particular we explored the association between cognitive outcome and those factors we hypothesized to be potential moderators of catch-up in the introduction. Table 3 displays the patterns of correlations between cognitive outcomes at 6 and 11 years in this "at risk" group and a range of factors including developmental level, weight, and head circumference at arrival in the U.K. and other potentially important moderators of outcome.

Few factors were associated with outcomes within the group over the age of 6 months on arrival at either age point. The main finding was an equivalent association between children's head circumference on arrival and IQ at the two ages and a slight but significant decrease in the level of association between the children's developmental level on arrival and the cognitive outcome at ages 6 and 11 years. Cognitive outcome did not differ by sex of child at either 6 or 11 years: 6 years GCI: boys mean $= 86.58$, $SD = 17.82$; girls mean $= 81.02$, $SD = 20.32$: $t(82) = 1.31$, *ns*; 11 years WISC: boys mean $= 88.58$, $SD = 13.31$; girls mean $= 83.70$, $SD = 15.60$: $t(84) = -1.56$, *ns*. Interestingly, there was no association between either parental NART score or parental educational status and IQ in the Romanian children who had experienced more than 6 months of deprivation. A multiple regression was carried out on the cognitive scores with head circumference measurements on arrival and the children's developmental level entered one by one. The children's head circumference on arrival contributed a significant 10% to the variability in cognitive scores at age 11, $R^2 = .096$, $F(1, 70) = 7.43$, $p < .01$, $\beta = .31$, $p < .01$. When the children's developmental level was added, it contributed a further significant 6% to the variability in the cognitive scores at age 11, $R^2 = .144$, $F(1, 69) = 5.80$, $p < .01$.

Table 3
Bivariate Correlations Between Deprivation-Related and Other Risk Factors and Cognitive Scores at Ages 6 and 11: Romanian Adoptees >6 Months on Arrival

	Cognitive outcome at 6 years	Cognitive outcome at 11 years
Denver quotient at arrival	.38***	.22
	($n = 79$)	($n = 79$)
Head circumference at arrival	.25*	.27*
	($n = 77$)	($n = 77$)
Weight at arrival	.21	.17
	($n = 82$)	($n = 82$)
Birth weight	− .01	− .04
	($n = 72$)	($n = 72$)
Parental NART score	.03	.09
	($n = 80$)	($n = 80$)
Parental educational level	− .01	− .04
	($n = 84$)	($n = 84$)

Note. At age 6 cognitive scores were measured on the McCarthy scales of children's abilities, and at age 11 on the WISC scales.
*$p < .05$, ***$p < .001$.

Table 3 shows that there was no significant main effect of subnutrition, as indexed by body weight, on variations in IQ at 11 in the group of institution-reared children who had entered the U.K. at age 6 months or older (the only group to show a cognitive deficit). Although well short of statistical significance, body weight at entry did have a correlation of .17 with IQ at 11. It remained just possible, therefore, that subnutrition might potentiate the effect of duration of institutional deprivation (which also had a nonsignificant effect—see above). To test this possibility, a two-way ANOVA was run using duration of institutional rearing (within the 6–42 month age at entry range) and weight at entry as dimensional variables and IQ at 11 as the dependent variable. No interaction was found. It remained possible, however, that subnutrition potentiated the stepwise increase in the effects of institutional care on rate of cognitive impairment that was found between the under 6 months and 6–42 months age of entry groups. This was examined by using a median split for weight at entry (which provided a cutoff at about the 3rd percentile) and a dichotomy for the presence or absence of cognitive impairment (with a cutoff at the 30th percentile). Chi-square findings were statistically nonsignificant and, using the Mantel–Haenszel statistic, there was no evidence of an interaction, $p = .614$. There was a nonsignificant tendency for subnutrition to have more of an effect in the group with an age at entry below 6 months, but this was a group in which the mean IQ did not differ significantly from that in the within-U.K. adoptees (who were not malnourished).

Discussion

The current results extend our understanding of the effects of severe early deprivation on cognitive development in seven main ways. First, they demonstrate that the effects of early institutional deprivation persist up to age 11 years, despite the children having spent at least $7\frac{1}{2}$ years in their adoptive homes. It is often supposed that the effects of experiences in infancy do not persist to any marked degree if there is a major discontinuity between early and later experiences (Clarke & Clarke, 1976; Kagan, 1979). That may well be the case with respect to many types of early experiences but it was not so with respect to the profound institutional deprivation in our sample. Thus, the children who were aged at least 6 months at the time of entering the U.K. had a mean IQ that was on average some 15 points below that for the group experiencing less than 6 months deprivation, as well as that for the within-U.K. adoptees. The implication is that some form of intraorganismic change was responsible for the mediation of long-term effects.

Three main possibilities exist (see Rutter, 2006, for an expanded discussion). First, there is animal evidence that severe stress experiences may damage the brain, perhaps especially the hippocampus (Bremner, 1999; McEwen, 1999). On the basis of a small positron emission tomography (PET) scan study, Chugani et al. (2001) argued that institutional deprivation similarly led to brain dysfunction, but there are uncertainties about their inferences (Rutter, 2006). Second, there is experience-expectant developmental programming in which normal somatic development *requires* particular experiences during the relevant sensitive phase if the appropriate somatic structure is to be laid down (Greenough, Black, & Wallace, 1987). The best-established model is provided by the role of visual input in the development of the visual cortex (see Hubel & Wiesel, 2004), but there are other examples (see Rutter, 2006). Third, there is the rather different concept of experience-adaptive developmental programming, in which a particular form of somatic development (both structural and functional) is shaped by the specifics of experiences during a sensitive period of development in such a way that there is optimal adaptation to the specifics of that environment (see Bateson & Martin, 1999; Caldji, Diorio, & Meaney, 2000; Sackett, 1965). The most obvious psychological example is provided by the evidence that phonological discrimination skills are increasingly shaped by the language of the rearing environment from about 6 months onward (Kuhl, 1994; Kuhl et al., 1997; Maye, Werker, & Gerken, 2002; Werker, 2003). With respect to institutional deprivation, the most directly relevant finding is the evidence from Fries, Ziegler, Kurian, Jacoris, and Pollak (2005) that children reared in Romanian orphanages and subsequently adopted by U.S. families showed changes in neuropeptides that were evident some 3 years postadoption. It is likely that this could have implications for psychological functioning, but these effects have not been investigated.

Second, there was some indication that, although the effects of early institutional deprivation were remarkably persistent, there was some attenuation with further cognitive catch-up between 6 and 11 years. Analysis showed that it was the degree of impairment at age 6 rather than the age of arrival in the U.K. that predicted catch-up, with only the most severely impaired children at age 6 showing significant catch-up between 6 and 11 years. Some of this catch-up is likely to have been a function of regression to the mean (Campbell & Kenny, 1999). Thus, as shown in Figure 1, there was a very slight tendency for there to be a fall in IQ for the children with the highest scores at 6 years. Nevertheless, the lack of any significant regression to the mean in the subgroup with IQ scores in the 15th–30th percentile range (see Table 2 and Figure 1) means that it is unlikely that regression to the mean constitutes a complete explanation. Rather, it is probable that there has been some true increase in IQ after age 6. The finding is in keeping with our earlier evidence that the catch-up between 4 and 6 years was greatest for children with lower cognitive scores at age 4 (O'Connor et al., 2000).

In the introduction we suggested a number of reasons as to why further catch-up might be expected. One possibility was that the influence of education might have been especially important in the cognitive domain (Cahan & Cohen, 1989; Morrison et al., 1995). However, our findings indicate that the period of schooling between 6 and 11 did not result in any overall rise in IQ in the institution-reared adoptees as a whole. Nevertheless, as Castle et al. (in press) show, extra individual help was more often provided for those with a lower IQ and lower scholastic attainments (as it should be). Accordingly, it could be that this special help contributed to the rise in IQ in the children with 6-year-old scores in the bottom 15%. The second main possibility is that it was the extra time in the adoptive home that enhanced the IQ. Most of the children in the bottom 15% did not come to the U.K. until they were 24–42 months of age. Our findings showed that age of entry per se did not account for the rise in IQ, but the extra time in the adoptive home may have been influential for the most cognitively impaired children. Whatever the explanation, the findings on the rise in IQ in this group suggest that, sometimes, continuing improvement may go on much longer than has been hitherto supposed (Skuse, 1984b).

The third main finding was that, despite this relative further catch-up, there was strong continuity in IQ between 6 and 11. Those children with marked intellectual impairment at 6 usually continued to show substantial impairment at age 11. The window of opportunity for intellectual gains postadoption between 6 and 11 years seems wider than appeared likely at 6, but there are clear limits, as shown by the relative persistence in cognitive impairment. The finding of developmental continuity with respect to intellectual impairment is in keeping with suggestions of developmental programming (see above) but the finding of change requires a different explanation. It is known that brain development is still continuing in adolescence (Huttenlocher, 2002), and that deprivation and enrichment can have neural effects even in adult life (see Greenough & Black, 1992; Greenough et al., 1987, for rat studies and Maguire, Frackowiak, & Frith, 1997, for a human example of the effects of intensive learning by taxi drivers on the structure of the hippocampus). There is also evidence that the human hippocampus retains its ability to generate neurons throughout life (Eriksson et al., 1998), although it is not known whether the same applies to other parts of the brain. The evidence is far too sparse for firm conclusions, but it seems that it may be possible for later experiences to alter some of the neural effects of early deprivation. Nevertheless, it is important to appreciate that the rise in IQ could be due to compensatory psychological strategies. Even less is known about their effects.

The fourth main finding was that, contrary to expectations based on the O'Connor et al. (2000) findings, there was no effect of variations in the duration of institutional deprivation (within the 6–42-month age of entry range) on individual differences in IQ at 11. There was no cognitive impairment associated with institutional deprivation that did not extend beyond the age of 6 months, but there was then a marked stepwise increase in cognitive impairment that was evident in those coming to the U.K. at any age above that, and no further increase as a function of any continuing institutional deprivation—at least up to the age of 42 months. The implication would seem to be that it takes some months for the institutional deprivation to have an adverse impact, but that once there is a negative effect, it is relatively enduring and not influenced by whether or not institutional deprivation continues. That constitutes a change from the findings at age 6, when there was a significant effect of duration of institutional deprivation, as shown in Table 1.

Further, our analyses showed that this was entirely because of the effects associated with marked cognitive impairment. When the bottom 15% was excluded, there was a zero effect at age 6 (a possibility not considered in our earlier report—O'Connor et al., 2000). The loss of effect was not just a consequence of a restriction in range because exclusion of the top 15% had no effect on the correlation between age at entry and IQ at 6.

In many respects this constitutes the most important, and certainly the most surprising, of our findings. The findings are similar for other outcomes such as disinhibited attachment, or language skills (Croft et al., 2006; Kreppner et al., 2006), so the conclusion is far from specific to cognition. One possibility is that the lack of effect of duration of deprivation is a consequence of the "statistical censoring" effect of the earlier death of the most vulnerable children—that is, the loss from the sample of the most vulnerable children. It is known that there was a substantial mortality in the Romanian institutions for younger children but there are no satisfactory statistics that could allow any quantification of this possible effect. If that does not account for the lack of effect of duration of institutional deprivation, other mechanisms will need to be considered, as noted above. Thus, neural damage or some form of developmental programming are the leading possibilities. We are investigating those possibilities through our ongoing structural and functional MRI study. However, what is unexpected in our results is that the enduring effects occurred as early as within 6–12 months of institutional deprivation, and that they did not increase with continuing deprivation. Theory is unhelpful in that it tends to suggest that there *should* be continuing effects (Clarke & Clarke, 2000). Nevertheless, there is the implication of some kind of sensitive period effect through which enduring changes occur and are relatively resistant to later influences. Animal studies would be helpful in investigating this matter.

The fifth key finding was that there was marked heterogeneity in outcome at both 6 and 11, as shown in Table 1 and Figure 1. There was no narrowing of the spread of IQ scores with increasing duration of institutional deprivation. There was a weak suggestion of a possible reduced variance at age 11, but this fell short of statistical significance except in one subgroup. The finding is an important reminder that major effects on level of IQ do not necessarily affect individual differences in IQ (see Duyme et al., 1999). It remains to be determined whether these individual differences reflect influences that are entirely independent of the deprivation, whether they reflect variations in the individual impact of the institutional experience, or whether they reflect differences (possibly genetically influenced) regarding sensitivity to institutional deprivation (Stevens, Sonuga-Barke, Asherson, Kreppner, & Rutter, in press).

The sixth key finding was that, although subnutrition (indexed by weight on arrival) constituted a major aspect of institutional deprivation, it had no significant effect on the cognitive outcomes at age 11. It is possible that severe subnutrition might have made children more vulnerable to the effects of psychological deprivation as well as directly contributing to the children's impaired physical development. Nevertheless, subnutrition at the time of U.K. entry did not moderate the effects of duration of institutional deprivation. Indeed, the trend was in the reverse direction from synergy. That is, the effect of subnutrition tended to be *less*, rather than greater, in those who experienced the most prolonged institutional deprivation. The result highlights the power of psychological deprivation independent of physical deprivation to create risk for cognitive impairment. The literature is of limited help in assessing this possibility because so few studies have attempted to make the contrast. Nevertheless, the finding is in keeping with the malnutrition studies in developing countries that show the effects of psychosocial influences (Grantham-McGregor et al., 1983, 2000). It should be noted, however, that our assessment of subnutrition relied on a single measure of weight obtained at the time of leaving the institution. We had no way of determining whether subnutrition was greater or lesser when the children were younger, and we had no measures of qualitative differences in patterns of malnutrition (as distinct from subnutrition). Also, because most of the Romanian adoptees were undernourished to a substantial degree, the range of variation was limited.

The seventh main finding was that individual differences in the adoptive families were largely unassociated with either the cognitive level at 11 or changes in cognitive level between 6 and 11. This does not mean that the adoptive family environment had no effect on cognition. The massive catch-up seen in the first 2 years postadoption clearly demonstrates the huge benefits of the adoptive family experiences. Rather the finding probably reflects three features. First, the range within the adoptive families was relatively small. This was evident in the spread of educational levels (which, as is usual in adoptive samples, was heavily skewed upward). In addition, however, the parents who adopted from Romania had to have unusual qualities of persistence and dedication to succeed in adoption. There were very few families who were not at least average, if not more so, in their commitment to effective child rearing. Second, there may well have been qualities in the details of childrearing relevant to cognitive growth that were not tapped by our measures. Thus, styles of parent–child communication and play that have been shown to be influential in other circumstances (see, e.g., Thorpe, Rutter, & Greenwood, 2003) could have been measured through observational measures, and parents could have been asked to report details of children's experiences that might be relevant for cognitive functioning. Budgetary constraints, as well as the need to limit the time requested from families, ruled out both in our study. Third, it could be that the massive effect of institutional deprivation so swamped other influences that there was little opportunity for the relatively small variations among the adoptive families to have an effect. It should be added, too, that previous research has shown that parental education exerts only a modest environmental influence on individual differences in IQ in adopted children (van Ijzendoorn, Juffer, & Poelhis, 2005). Thus, Neiss and Rowe (2000) found correlations of only .16–.18 between adoptive parents' educational level and that of the adopted children's verbal IQ.

In summary, the study indicates that there were persistent effects of deprivation on cognitive development at age 11, but that there was significant improvement over time for the children with the lowest IQ scores at age 6, with a loss at age 11 of the dose–response relationship between age at entry (length of deprivation) and IQ found at 6. Most strikingly, there was no measurable effect of institutional deprivation that did not extend beyond 6 months of age, but a substantial decrement in IQ associated with any duration of institutional deprivation above that age.

The findings are consistent with some aspects of current thinking about cognitive development and about plasticity, but raise challenges about other aspects. Thus, our finding of both strong continuity and important change fits in with a much broader body of research and theory (Grossman, Grossman, & Waters, 2005; Rutter, Kim-Cohen, & Maughan, 2006; Rutter & Rutter, 1993). The evidence of change is also consistent with the evidence that neural plasticity continues into adolescence and adult life, and is not restricted to the infancy period (Huttenlocher, 2002). The challenges to theory especially derive from the finding that there are no measurable later effects of profound institutional deprivation that does not extend beyond 6 months of age, that there are then substantial enduring effects from any experience of institutional deprivation that lasts longer than that (even just up to 12 months), that such effects are apparently not increased by the length of deprivation in the range above 6 months, and that there is such marked heterogeneity in outcome. The enduring effects are consistent with both findings and theory with respect to biological programming (Rutter, 2006; Rutter et al., 2004), but the heterogeneity calls for a different explanation. The growing evidence of gene–environment interactions (Rutter, Moffitt, & Caspi, 2006) suggests that at least part of the explanation may lie in genetically influenced variations in susceptibility to environmental hazards. This possibility should be high on the research agenda.

Lastly, we need to consider the extent to which our findings can be generalized to less severe forms of deprivation and to deprivation in family, rather than institutional, contexts. The question cannot be answered on the basis of research because the relevant contrasts and comparisons have yet to be undertaken. It is likely that the developmental principles will be generalizable but, equally, it must be expected that the specifics may vary according to the nature and timing of adverse experiences, and to the qualities of the environment to which children move when leaving the situations that provided risk.

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