Are There Biological Programming Effects for Psychological Development? Findings From a Study of Romanian Adoptees

Michael Rutter, Thomas G. O'Connor, and the English and Romanian Adoptees (ERA) Study Team
Institute of Psychiatry

Associations between experiences and outcomes could be due to (a) continuation of adversity or (b) organismic changes, including experience-expectant and experience-adaptive developmental programming. The adoption into British families of children who had been reared in profoundly depriving institutions in Romania presented an opportunity to test mechanisms. Romanian children reared from infancy in very depriving institutions for periods up to 42 months were compared with 52 nondeprived UK-born children placed into adoptive families before the age of 6 months. The results at 6 years of age showed substantial normal cognitive and social functioning after the provision of family rearing but also major persistent deficits in a substantial minority. The pattern of findings suggests some form of early biological programming or neural damage stemming from institutional deprivation, but the heterogeneity in outcome indicates that the effects are not deterministic.

During the 1950s to 1970s, strong claims were made regarding the supposed permanent effects of early adverse experiences and also about the importance of critical periods in development that required particular experiences to occur during a narrow time frame for normal development to proceed (Bowlby, 1951; Klaus & Kennell, 1976; Pilling & Kellmer-Pringle, 1978; World Health Organization Expert Committee on Mental Health, 1951). Both claims failed to be supported by empirical research findings, at least with respect to their strong form (Bateson, 1966; Bornstein, 1987; Rutter, 1981; Sluckin, 1973), and the concepts went out of fashion. It came to be accepted that experiences at all ages could be influential and that the extent to which the effects of adverse experiences did or did not persist depended in large part on whether the early disadvantage or deprivation was followed by later disadvantage or deprivation (Clarke & Clarke, 1976, 2000). During the 1990s, there was a reemergence of these earlier claims in a slightly different form, supposedly supported by neuroscience findings on early brain development and on the ways in which such development is sculpted and shaped by early experiences (see Bruer, 1999, for a critique).

In this article, we seek first to clarify the relevant theoretical notions and then to use our data set on children reared in extremely depriving Romanian orphanages, who were subsequently adopted into United Kingdom (UK) families at ages ranging from infancy to 3½ years and then followed up at the ages of 4 and 6 years (they have recently been reassessed at 11–12 years), in order to test alternative causative models. The sample provided a particularly striking example of a "natural experiment" (see Rutter, Pickles, Murray, & Eaves, 2001) in which there was a sharp discontinuity between early and later rearing environments and in which the change was extremely sudden (and thus easy to time exactly) and also involved an unusually radical shift from a profound and pervasive institutional deprivation to somewhat above-average rearing circumstances in a low-risk family setting. The key question is whether, given the high quality of the later environment, there were any persisting sequelae and, if there were, to what they might be due.

Possible Mediators of Persisting Effects of Psychosocial Adversity

The starting point is the evidence from previous research that, in certain circumstances, there may be long-term sequelae of adverse early experiences; the question to be addressed concerns the possible mechanisms underlying such effects (Rutter, 1989, 2000, 2002a). Three main types of possibility need to be considered. First, the persistence of effects might be brought about by continuities in psychosocial adversity, the main influence deriving from the current (rather than the past) environment (Clarke & Clarke, 1976, 2000). This view builds on the evidence that early adverse experiences frequently lead people to behave in ways, or put themselves in circumstances, that predispose them to a recurrence of psychosocial adversities, not necessarily of the same kind. For example, studies of institution-reared children have shown that many feel that they have a lack of control over their lives and, for that reason, tend to respond impulsively to difficulties, leaping out of one stressful situation into another that may be even more damaging (Pawlby, Mills & Quinton, 1997; Pawlby, Mills, Taylor & Quinton, 1997; Quinton, Pickles, Maughan, & Rutter, 1993; Quinton & Rutter, 1988; Rutter & Robins, 1990).

A second alternative is that the persistence or otherwise of the psychological effects of psychosocial adversity is determined by

the individual's cognitive/affective processing of the experiences. According to this view, the main lasting influence derives from the person's interpretation of, or thoughts about, the experiences. There is no doubt that even quite young children do actively process their experiences, and the notion that the mental sets that they develop about themselves and their experiences could constitute the key mediating influence for later effects is a plausible one (Main, Kaplan, & Cassidy, 1985). On this basis, Kagan (1980) hypothesized that the main reason why, on the whole, very early experiences so rarely had enduring effects was a consequence of infants' much more restricted ability, compared with the abilities of older children and adults, to engage in active processing. Moreover, although there is evidence that even young infants can and do remember events over periods of months, it is uncommon for older children and adults to have memories of discrete events in the first 2 years (Bruce, Dolan, & Phillips-Grant, 2000). It seems that this lack of early memories (so-called infantile amnesia) probably arises, at least in part, because retrieval is hampered by the major differences between cognitive concepts in infancy and those in middle childhood and beyond (Howe & Courage, 1993; Rutter, Maughan, Pickles, & Simonoff, 1998). It has proved difficult to put cognitive/affective processing notions to the test in a rigorous fashion, even in the postinfancy period. Nevertheless, there is good evidence that young people themselves develop internal working models of their experiences and of their interactions with others (Bretherton & Mulholland, 1999; Teasdale & Barnard, 1993). Moreover, there are modest pointers that cognitive/affective processing may play some part in the transduction of adverse experiences into maladaptive behavior (Dodge, Pettit, Bates, & Valente, 1995).

The third alternative is that early adverse experiences bring about a lasting change in the organism, with the main influence deriving from an enduring effect on somatic structure and function. That this can occur is clearly shown by the animal evidence on the effects of early stress experiences on the structure and function of the neuroendocrine system (Bakshi & Kalin, 2000; Barbazanges et al., 1996; Francis, Diorio, Liu, & Meaney, 1999; Hennessey & Levine, 1979; Schneider & Moore, 2000). In recent years, the concept has increasingly been applied to the effects of experiences on the brain.

Implications of Alternative Hypotheses on Mediators

Each of these postulates has a rather different set of predicted consequences, which help in determining how the alternatives may be pitted against one another in a research design.

Continuation of Adversity

The first possibility, that the effects derive from the continuation of adversity, implies that the sequelae should be largely reversible if there is a sufficiently radical change in the relevant environmental circumstances and if the later environment provides persistent high quality. It also follows that later functioning should vary systematically according to differences in the quality of the later environment. There are no particular implications for predicted age-specific effects, although cumulative effects may be anticipated. At the time when this study was first planned, more than a decade ago, this was our favored hypothesis (Rutter, 1981).

Cognitive/Affective Processing

The second alternative gives rise to a quite different set of predictions. The implication is that the sequelae should be much less marked if the adverse experiences were restricted to an age period when an individual had a rather limited capacity to process experiences and when later amnesia for early events is to be expected. Clearly, the cognitive/affective processing skills are likely to function dimensionally rather than categorically. Because of the evidence suggesting that early established attachment qualities together with their mental sets or internal working models are modified by later experiences if these are very different (Kobak, 1999; Thompson, 1998), it may also be anticipated that there will be limited persistence, and continuing change, if the children's later experiences are good and are relevant to the sequelae being considered. In view of our findings on the role of a cognitive style of planning (Quinton & Rutter, 1988), we hypothesized initially that cognitive sets might play a key role in psychological outcomes.

Lasting Changes in the Organism

The hypothesis that effects derive from lasting changes in the organism implies a quite different set of expectations. Because persistence is postulated to derive from changes in somatic structure, it may be anticipated that only a limited recovery is likely to be possible (although, of course, some effects of some sorts of stress can be reversed—see Maccari et al., 1995). Also, the extent of the sequelae should be more strongly associated with the duration of adverse experiences in early life than with the length of time in the compensatory good environment later. Later functioning should *not* vary greatly according to differences in the qualities of the later environment. If the organismic changes affected brain growth, the sequelae might be associated with head size, because this constitutes an index of brain growth.

Possible Types of Changes in the Organism

First, there must be a neural substrate for all forms of learning. This carries with it no particular implications for persistence because the effects of early learning can be altered by later learning—what Greenough, Black, and Wallace (1987) have termed *experience-dependent effects*. Thus, memories and acquired knowledge are laid down, can be retrieved later, and can be modified by new learning or new experiences. Our understanding of the precise brain processes that are involved remains quite limited, particularly with respect to functioning in humans, but there is no doubt that there is a neural substrate for learning (see Rutter, 2002b).

Second, there is animal evidence that severe stress experiences may damage the brain (McEwen, 1999). Thus, for example, this has been shown in relation to changes in the hippocampus (Bremner, 1999). The implication in this case is that there are likely to be some persisting consequences for mental functioning. To date, uncertainties remain about the extent to which the animal findings can be extrapolated to humans, and there is even more uncertainty about the links between brain structure and the functioning of the mind. Nevertheless, this mechanism certainly seems to have validity.

The third possible type of change in the organism concerns the operation of developmental programming during a sensitive period of development. This implies a lasting alteration of the soma that takes place during a maturational phase in which the organismic structure is being laid down and in which the establishment of that structure is shaped by experiences. The implication is that the changes brought about during this sensitive period of development involve influences on later function and on adaptation to later environments.

Different Concepts of Developmental Programming

There are at least two different concepts of developmental programming: experience-expectant and experience-adaptive, the implications of which are rather different.

Experience-Expectant Developmental Programming

The first concept implies that normal somatic development *requires* particular experiences during the relevant sensitive phase of development if the appropriate somatic structure is to be laid down (Greenough et al., 1987). The best-established model here is that provided by the role of visual input in the development of the visual cortex. This was first shown by Hubel and Wiesel (1965; Hubel, Wiesel, & Le Vay, 1977) and has since been confirmed by numerous other investigators (Blakemore, 1991). Normal visual functioning in later life is dependent on adequate visual input in infancy (Le Grand, Mondloch, Maurer, & Brent, 2001). In humans, this is evident, for example, in the finding that unless strabismus (a visual squint) is corrected in the first few years, normal binocular vision later is unlikely. Animal studies have shown that, to a very limited extent, there may be later modification of these effects, but the modifications are rather marginal in most circumstances.

The implication of this concept of experience-expectant development is that the required experiences cover a very broad range of expectable environments and *not* variations within the normal range. It is also to be expected that a lack of such experiences will interfere with normal somatic structural and functional development irrespective of the nature of later environments. These effects, however, operate only within the sensitive period of development in which the somatic structure is being established. Insofar as the experiences (albeit within a broad range) are regarded as essential for normal somatic development, marked individual differences that include normal functioning are not to be expected.

Experience-Adaptive Developmental Programming

The concept of experience-adaptive development is quite different. It implies that the particular form of somatic development, both structural and functional, is shaped by the specifics of experiences during a relatively sensitive phase 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). This concept has been written about most extensively in relation to the findings with respect to the role of early subnutrition in bringing about a much-increased risk for later coronary artery disease, hypertension, and diabetes because the programming has been for low nutrition and not the richer diets

encountered in adulthood (Barker, 1997; O'Brien, Wheeler, & Barker, 1999). The finding is particularly interesting from a developmental point of view because the correlates are the opposite of those found in later life. That is, although early subnutrition is associated with an increased risk of later coronary artery disease, in midlife the risk comes from overnutrition. So far, the physiological basis of these findings remains ill-understood, but the theoretical notion is that the organism is programmed to deal with poor nutrition and that it is thereby maladapted to deal with later overnutrition, if that is what is encountered in the later years. There are similar sorts of effects in relation to immunity and infection (Bock & Whelan, 1991).

The most obvious likely parallel within the field of psychological development is provided by phonological development. Infants in all countries show broadly comparable skills in phonological discrimination, but from the second half of the 1st year onward, phonological discrimination skills are increasingly shaped by the language of the rearing environment (Kuhl, 1994; Kuhl et al., 1997). Thus, it has often been observed that Japanese people find great difficulty discriminating *r* from *l*, a discrimination that is taken for granted by those who have been English speakers from infancy onward.

The implications of this form of developmental programming are the same as those for experience-expectant development only with respect to the postulate that the effects will operate exclusively within the sensitive period of development when the somatic structure is being established. The two key differences are, first, that the relevant experiences and outcomes include variations within (as well as outside) the normal range and, second, that the nature of such experiences will foster somatic development that is well adapted for the environment experienced during the sensitive phase. Whether such development will be well adapted for later environments will depend on whether they are similar to, or different from, those provided by early experiences. In other words, the development that has been shaped by the early experiences cannot be regarded as normal in an absolute sense; rather, it is adapted to a particular type of environment.

Hypotheses

The research design with respect to data analysis was determined by the need to test competing hypotheses about the effects of profound early deprivation. Five main alternatives were considered:

1. The effects are entirely due to subnutrition rather than to psychological deprivation. The expectation in this case is that there should be a major effect on outcome of nutritional level (as indexed by weight) at the time of leaving Romania and that duration of institutional care should no longer relate to psychological outcomes after nutrition is taken into account.

2. Psychological outcome is primarily determined by the qualities of the environments prevailing at outcome. The expectation in this case is that there should be complete recovery if the later environments are of high quality, and insofar as there are any deficits, these should be a function of later environmental limitations and not of the earlier adversities.

3. Psychological outcome is primarily determined by the cognitive/affective mental sets or internal working models that the children develop about their experiences and about the implica-

tions for their concepts of themselves as individuals. The expectation in this case is that the sequelae should be least marked when children's ability to process experiences is most limited and when their later memories of such experiences will be weakest. On this basis, the prediction is that psychological sequelae (in relation to social outcome) should be least severe for children whose developmental level at the time of entry into the UK was below 1 year.

4. Psychological outcome is primarily determined by experience-adaptive biological programming. The expectation that follows is that psychological deficits at follow-up should be a function of the pervasiveness of the early institutional deprivation, as indexed by the duration of institutional care, and not of the qualities of the later environment. Because this form of programming concerns adaptations within the normal range, no effect on brain growth is expected.

5. Psychological outcome is primarily determined by either experience-expectant biological programming or by neural damage (we saw no clear way of differentiating between these two alternatives with the measures available to us). The predictions are similar to those for Hypothesis 4 except that there might be associations with head growth, on the grounds that if the experiences are required for normal brain development, some impairment of brain growth (resulting in diminished head growth) might be expected.

Psychological Outcomes

In this article, we focus on just two contrasting psychological outcomes: (a) cognitive impairment and (b) disinhibited attachment. The rationale was that we wished to compare two outcomes for which the evidence suggested that somewhat different psychosocial influences might be operative (Rutter, 1985a, 1985b, 2002a) and hence that, possibly, different mediating mechanisms might be relevant.

Method

Sample

The sample of adoptees from Romanian institutions was drawn from the 324 children adopted into UK families between February 1990 and September 1992 who were processed through the Department of Health and/or the Home Office. A stratified random sampling design, based on the child's age at the time of coming to the UK, was used. Overall, 81% of the parents of Romanian adoptees who were approached agreed to participate. The study sample as a whole ($N = 165$) included a few children who were adopted from a home setting, but in this article we confine attention to the 144 who were reared from infancy in very depriving institutions and who were adopted into UK families at various ages up to 42 months. There were 45 children placed at under 6 months, 54 placed between 6 and 24 months, and 45 placed between 24 and 42 months. The last group was too old at the start of the study to be assessed at 4 years of age, but these children were evaluated at age 6 in exactly the same fashion as the other groups. The findings in this article are confined to the assessments at age 6 and therefore cover the whole sample of 144 institution-reared children.

The comparison sample comprised 52 UK-born children who were placed into adoptive families before the age of 6 months. The choice of this sample was dictated by our wish to equate the groups with respect to the experience of adoption but to seek a contrast with respect to early experiences. Social Service records indicated that none of the comparison sample had been removed from parents because of abuse or neglect and

none had experienced an institutional rearing. The decision to focus on a group adopted before 6 months of age was predicated on the wish to have a "best case" adoption sample. The interest in the duration of deprivation was relevant only within the Romanian sample and not within the comparison group, who had not experienced severe deprivation. Accordingly, there were no late-adopted UK-born children. Intracountry adoptees were obtained through adoption agencies and social services departments. It was not possible to determine the rate of participation among the intracountry adoptees because a name was provided to the project by the adoption agency only after the family consented to participate. Available information suggests that approximately 50% of the families who were contacted agreed to participate.

The adoptive families of both UK and Romanian children were generally middle class and slightly better educated than the general UK population but did not differ in these respects from one another (Rutter & the ERA Research Team, 1998). Differences that did exist between parents adopting from the UK and from Romania were a direct consequence of UK adoption policies (e.g., with respect to the presence of biological children in the family); these demographic variables were not associated with outcomes and were therefore dropped from the analyses. Among the families adopting from Romania, no association was found between family characteristics and the child's age at entry into the UK. Also, children who entered the UK at a relatively young age were similar to those who entered later in terms of the age when they were placed in the institution and in terms of subnutrition at entry into the UK (O'Connor, Rutter, Beckett, et al., 2000). In the great majority of cases, the Romanian children entered the institution in early infancy (85% within the 1st month of life), and it is evident that institutionalized children were not placed there because of developmental delay or handicap. Children adopted from Romania had experienced unusually severe and pervasive deprivation (Castle et al., 1999), as reflected in their marked physical and developmental delay evident at the time of UK entry (Rutter et al., 1998).

Measures

A wide range of measures was obtained similarly on all children at the ages of 4 and 6 years (see Kreppner, O'Connor, Dunn, Anderson-Wood, & the ERA Study Team, 1999; Kreppner, O'Connor, Rutter, & the E.R.A. Study Team, 2001; O'Connor, Bredenkamp, Rutter, & the English and Romanian Adoptees (ERA) Study Team, 1999; O'Connor, Rutter, Beckett, et al., 2000; O'Connor, Rutter, & the English and Romanian Adoptees Study Team, 2000; Rutter, Kreppner, O'Connor, & the ERA Study Team, 2001; Rutter et al., 1998, 1999). Details are given here only of the physical, cognitive, and social measures used in the present set of analyses.

Measures concerning the child's state at the time of UK entry. Weight at the time of the child's entry to the UK, which indexed nutritional deprivation, and head circumference, which indexed brain growth, were assessed in terms of standard deviation units with respect to population norms. Thus, a score of –1.5 indicated a score 1.5 standard deviations below average (Boyce & Cole, 1993, based on the work of Buckler, 1990). Developmental assessment was available on the Romanian children and was based on retrospective parental reports on the Revised Denver Prescreening Developmental Questionnaire (R–PDQ; Frankenburg, van Doorninck, Liddell, & Dick, 1986). Previous analyses (showing the concurrent and predictive correlations with the children's scores on the McCarthy Scales of Children's Abilities) supported the validity of these retrospective measures (Rutter et al., 1998).

Measures at age 6 years. At both 4 years and 6 years of age, the families were visited at home by a trained interviewer for a tape-recorded intensive interview with the primary caregiver and the administration of a set of behavioral and family-related questionnaires. Approximately 3 months later, an extensive assessment of the child was conducted by different research workers, using standard cognitive and developmental measures and observations. For the present purposes, attention is confined

to the general cognitive index (GCI) of the McCarthy Scales of Children's Abilities (McCarthy, 1972)—a widely used measure of intellectual functioning that comprises four subscales: Verbal, Quantitative, Perceptual, and Memory. A small subset of 5 late-placed children did not attain a basal score on the GCI at age 6: The Merrill-Palmer Scale was administered to those children, and a GCI score was imputed on the basis of the Merrill-Palmer Scale results.

Evidence for disinhibited attachment disturbance was derived from a semistructured interview designed to assess the child's behavior toward the parent and other adults in both novel and familiar situations. Three items indexed disinhibited behavior: a definite lack of differentiation among adults; a clear indication that the child would readily go off with a stranger; and a definite lack of checking back with the parent in anxiety-provoking situations. For each of these items, a score of 0 was given if there was no evidence of the specified behavior; a score of 1 was given if there was some or mild evidence; and a score of 2 was given if the behavior was marked or pervasive. The scores for each of the three items were then summed. For the current sample, internal consistency was .77. Interrater reliability on each of the items from the interviews was determined, using a weighted kappa statistic, for 20 interview protocols from 3 interviewers. Kappas ranged from .86 to 1.00. In order to identify children with severe social disinhibition, we used a cutoff score of 4 or more on the 6-point scale, which identified about 1 in 9 of the sample. Previous analyses had indicated that this measure was closely associated with the presence and duration of deprivation (O'Connor et al., 1999). The attachment classification findings based on the modified separation–reunion procedure, used at age 4, were used to validate the parents' descriptions of disinhibited behavior (O'Connor et al., 2003). Compared with the remainder of the sample of Romanian adoptees, the children with disinhibited attachment patterns were significantly less likely to show secure attachment (13% vs. 45%) and much more likely to show an "other" nonnormative pattern (81% vs. 39%). This pattern was based more on the response to the stranger than on the response to the mother, either before separation or after reunion. An unusually friendly initial approach to the stranger was common, but this was sometimes followed by later wariness. However, probably what was most characteristic was coy, silly, overexuberant, or overexcited behavior. The validation provided a rigorous test in that the videotaped child observations were rated by raters blind to group. It may be concluded that parents were describing a quite unusual pattern of behavior of a distinctive kind.

Of the original sample of 144, all were followed up at 6 years of age with parental interviews. In 8 cases, parents declined permission for the children to be interviewed and tested, so direct child measures were available for 136 (94%) of the sample. The main sources of missing data were the weight at the time of UK entry (13 missing) and head circumference at entry (11 missing). Parent estimates on child nutrition were available for missing cases, and the findings were analyzed using these in the place of missing data, with almost identical results. However, data are reported here strictly in terms of actual quantified measures obtained at the time. Follow-up parental interviews when the children were 6 years old were obtained for all of the 52 within-UK adoptees, and direct child measures were available for 50 (96%).

Analytic Strategy

A multistage analytic strategy was followed. First, as already established in published analyses (Rutter, Kreppner, et al., 2001), the hypothesis of a specific effect of institutional deprivation on cognitive impairment and on disinhibited attachment had been tested by determining whether these variables showed both a between-groups difference (between Romanian adoptees and within-UK adoptees) and a within-group difference according to the duration of institutional deprivation. Second, again as already published, although subnutrition had a significant effect on cognitive outcome at the age of 6 years, a large effect of duration of deprivation remained after

nutrition was taken into account (O'Connor, Rutter, and the English and Romanian Adoptees Study Team, 2000). There was no effect of subnutrition on disinhibited attachment (O'Connor, Rutter, Beckett, et al., 2000). Nevertheless, because subnutrition constituted a potentially important confound, it was included in the new analyses reported here. Third, developmental catch-up was considered with respect to weight because previous research had shown that weight catch-up was usually complete or nearly complete (i.e., there was no developmental programming). Fourth, catch-up for head circumference (which is strongly related to brain growth) was assessed to determine whether or not it followed the pattern for weight. Fifth, cognitive catch-up was assessed at age 6 through comparison of cognitive levels with those of the within-UK adoptee group. Sixth, the competing hypotheses on mechanisms were tested through examination of the correlates of cognitive level at age 6, with particular attention given to head circumference (as an index of biological underpinning) and adoptive parental educational level (as an index of the home rearing environment). Seventh, a parallel examination of competing hypotheses was undertaken with respect to disinhibited attachment, with the same attention paid to head circumference but also to the children's developmental level at the time of UK entry (as an index of cognitive processing abilities at that time). Eighth, the temporal stability of deficits between 4 years and 6 years was examined to determine whether there was persistence of the effects of the early adverse environment. Finally, there was an examination of the heterogeneity in outcome. Because our hypotheses included the possibility of effects only on subgroups, and because prior analyses had shown no effects for children who left institutional care at younger than 6 months, we used categorical, as well as dimensional, approaches (see Farrington & Loeber, 2000). In all cases, we checked whether the findings using dimensional measures were similar and found that they were.

Results

Patterns Associated and Not Associated With Institutional Deprivation

The first step in the analytic strategy—namely, testing for the associations between each of the two outcome variables and institutional deprivation—had already been taken in previously published studies (O'Connor, Rutter, Beckett, et al., 2000; O'Connor, Rutter, and the English and Romanian Adoptees Study Team, 2000). In brief, cognitive impairment (defined here as a McCarthy test GCI of less than 80) occurred in 15.4% of the institution-reared adoptees from Romania, compared with 2.0% of within-UK adoptees ($p = .01$ on two-sided Fisher's exact test). There was a linear association with duration of institutional care, with 2.3% cognitive impairment in those experiencing 6 months or less of institutional deprivation, 12.0% cognitive impairment in those experiencing greater than 6 but not more than 24 months, and 32.6% in those experiencing greater than 24 but not more than 42 months, $\chi^2(1, N = 136)$ for trends $= 15.12$, $p < .01$. The comparable figures for disinhibited attachment behavior were 22.4% versus 3.8% ($p = .002$) for Romanian and UK adoptees, respectively, and 8.9% versus 24.5% versus 33.3% for ≤ 6 months, > 6 but ≤ 24 months, and >24 but ≤ 42 months, respectively, $\chi^2(1, N = 143)$ for trends $= 7.69$, $p < .01$. In most of the remainder of the article, attention is confined to the 99 children who left Romanian institutions after the age of 6 months, because no significant deficits were found in those who entered the UK below that age.

Developmental Catch-Up and Deficits for Weight and Head Circumference

Previous research had shown that severely malnourished children usually showed a catch-up in growth once normal nutritional intake was provided (e.g., Lien, Meyer, & Winick, 1977). The next step, therefore, was to determine whether that was so in our sample. Table 1 shows the catch-up in weight for the 58 children whose weight at the time of entry into the UK was at least 1.5 standard deviations below the UK population mean for their age group and sex (i.e., the sample used here includes only those children showing severe subnutrition). Those whose weight at entry was higher than that were excluded because the question of catch-up could not apply in the same way. Despite the fact that half the total group of Romanian adoptees had a weight below the third percentile, the catch-up in weight for those who left the institution between the ages of 6 and 24 months was virtually complete by the age of 6 years. There was a similarly dramatic catch-up in those who remained in the institution until after age 2, but the catch-up was not quite complete by age 6.

The next analytic step was to determine whether the catch-up in head growth followed the same pattern as that found for weight. Table 2 shows the findings for head circumference in the Romanian adoptees with and without severe subnutrition. Strikingly, although there was very substantial, and highly significant, catch-up for both those with and those without severe subnutrition, the catch-up in head circumference was far from complete. For those without severe subnutrition at the time of UK entry, head circumference at age 6 was still about 1½ standard deviations below the general population mean. For those with between 6 and 24 months of institutional deprivation, the findings at 6 years differed significantly from those for weight (as shown by the lack of overlap between the confidence intervals). In short, significant head-circumference deficits persisted even when weight catch-up was largely complete. A multivariate, using a within-subject, repeated measures analysis (with time, head circumference, and weight as within-subject measures), revealed a significant interaction between measure and time, $F(1, 47) = 32.24$, $p < .01$, as well as a main effect of time. That is, the catch-up for weight was significantly greater than the catch-up for head circumference. The finding that the pattern for head circumference differed from that for weight means that the continuing impaired head growth found in some children could not be accounted for solely in terms of the effects of malnutrition on overall body growth.

Cognitive Catch-Up and Deficit

Cognitive progress was assessed by using the initial R–PDQ developmental quotient at the time of UK entry as the starting point and the McCarthy GCI at age 6 as the outcome. In the group of Romanian adoptees as a whole, over half were initially functioning in the severely retarded range, and by age 6 their cognitive functioning had almost caught up to the UK population mean (O'Connor, Rutter, Beckett, et al., 2000). This was so for both those with and those without severe subnutrition initially, although the catch-up was less complete in those who remained in the institution longest and who were severely subnourished.

The further question, however, was whether, despite the dramatic catch-up, there was a persistent cognitive deficit at age 6 in those who remained longest in the profoundly depriving institutional care (see Table 3). No deficit was found in the Romanian adoptees from institutions who entered the UK before the age of 6 months ($M = 114.2$; 95% confidence interval [CI] $= 108.8–119.7$; $n = 44$), their GCI scores not being significantly different from those of the within-UK adoptees ($M = 116.7$; 95% CI $= 111.6–121.7$; $n = 50$). This was so for both those with ($M = 108.8$; 95% CI $= 102.3–115.3$) and those without ($M = 122.9$; 95% CI $= 113.7–132.2$) severe subnutrition. By sharp contrast, deficits were apparent in those whose institutional care continued for more than 6 but less than 24 months and for those for whom it continued for more than 24 but less than 42 months. This was apparent in both those with and those without severe subnutrition. The greatest deficit, however, was found in those who remained in the institutions longest and who had severe subnutrition. Moreover, the deficit in the mean scores of those who came to the UK after 6 months compared with those adopted within the UK in infancy was quite substantial—some 18–25 points in those who were not malnourished and 18–35 points in those who were malnourished.

Because, with very few exceptions, the children moved without any appreciable time gap from institutional care to the adoptive home in the UK, cross-sectional data did not allow differentiation between the effects of duration of institutional privation and the effects of the length of time in the adoptive home. However, this contrast could be made through use of longitudinal data (by making use of the continuities between the scores at 4 years and 6 years). In order to make this contrast, we confined attention to Romanian adoptees, all of whom had been in their adoptive homes for 2½ to 4 years but who varied in their duration of exposure to institutional rearing. Because the findings on the dose–response

Table 1

Weight (in Standard Deviation Units) Catch-Up by Age at UK Entry in Romanian Adoptees With Severe Subnutrition

	Weight at entry			Weight at 6 years		
Age at UK entry	M	95% CI	n	M	95% CI	n
>6 but ≤24 months	−3.21	−3.67 to −2.77	35	−0.35	−.70 to −.01	32
>24 but ≤42 months	−4.10	−5.42 to −2.77	23	−1.16	−1.55 to −.77	23

Note. Severe subnutrition was defined as weight 1.5 *SD*s below United Kingdom (UK) population norms at the time of entry into the UK. A repeated measures analysis of variance indicated a significant effect of time, $F(1, 53) = 94.08$, $p < .01$, and group, $F(1, 53) = 5.57$, $p < .05$, but no interaction, $F(1, 53) = 0.02$ (i.e., the extent of catch-up was the same across groups). The means at entry were not significantly different, but those at age 6 were, $F(1, 53) = 9.68$, $p < .01$. CI = confidence interval.

Table 2
Head Circumference (in Standard Deviation Units) Catch-Up According to Age at UK Entry in Romanian Adoptees With and Without Severe Subnutrition

Age at UK entry	Head circumference at entry			Head circumference at 6 years		
	M	95% CI	n	M	95% CI	n
>6 but ≤24 months						
Without severe subnutrition	−2.27	−2.83 to −1.69	17	−1.60	−2.00 to −1.19	16
With severe subnutrition	−2.77	−3.28 to −2.26	32	−1.63	−1.98 to −1.29	32
>24 but ≤42 months						
Without severe subnutrition	−2.23	−3.09 to −1.38	11	−1.32	−1.77 to −0.87	12
With severe subnutrition	−3.37	−4.09 to −2.66	21	−2.52	−3.00 to −2.03	22

Note. Severe subnutrition was defined as weight 1.5 *SD*s below United Kingdom (UK) population norms at the time of entry into the UK. A repeated measures analysis of variance indicated a significant effect of time, $F(1, 71) = 33.87$, $p < .01$, and group, $F(3, 71) = 5.25$, $p < .01$, but no interaction, $F(3, 71) = 0.18$. CI = confidence interval.

effect of duration of institutional care were derived from the total sample, this analysis was also undertaken with the total sample (i.e., including those with less than 6 months in institutions). The subgroup of 84 children (79 of whom had cognitive data available) whose institutional care had lasted for no more than 18 months had a mean GCI of 108.2 (95% CI = 104.1–112.3). By sharp contrast, those whose institutional care had lasted between 24 and 42 months ($n = 60$, 57 with available cognitive scores) had a mean score of 88.1 (95% CI = 82.0–94.1). There was only limited further cognitive catch-up between 4 and 6 years of age, and the catch-up that was observed was unrelated to duration of deprivation but was instead associated with lower cognitive scores at the earlier assessment (see O'Connor, Rutter, Beckett, et al., 2000). It is evident that the effect of duration of institutional care was extremely strong, even after the period of time in the adoptive home was taken into account. The deficit on this comparison amounted to some 20 IQ points.

Correlates for Cognitive Functioning and Cognitive Impairment

Apart from the effects of duration of institutional care, the only major correlate with cognitive functioning was the head circum-ference both at the time of UK entry and at age 6. The 21 children with a GCI score below 80 at age 6 had a head circumference that was approximately 1 standard deviation lower than that of those without cognitive impairment, the differences at both time points being statistically significant. At the time of UK entry, the means (and 95% CIs) were −2.38 (−2.70 to −2.07) for the 115 children with a cognitive score above 80 at age 6 and −3.39 (−4.01 to −2.78) for the 20 children with a cognitive score of less than 80 at age 6. At 6 years, the comparable figures were −1.52 (−1.71 to −1.32) and –2.22 (−2.78 to −1.65). There were significant main effects on cognitive level for time, cognitive impairment, and nutritional deprivation, but no significant interactions of any kind in a repeated measures analysis.

These differences in cognitive scores were not just a function of subnutrition. Indeed, in the group without subnutrition, there was still a significant effect of head circumference at the time of UK entry on cognitive impairment at age 6 (for those without impairment, $M = −1.59$, 95% CI = −2.08 to −1.1; for those with cognitive impairment, $M = −3.01$, 95% CI = −4.49 to −1.55), $F(1, 40) = 4.91$, $p < .05$. The difference for head circumference at age 6 was in the same direction ($Ms = 1.16$ vs. 1.43), but it fell well short of statistical significance, $F(1, 42) = 0.45$. The corre-

Table 3
Cognitive Catch-Up by Age at UK Entry in Romanian Adoptees With and Without Severe Subnutrition

Age at UK entry	R–PDQ score at UK entry			GCI at 6 years		
	M	95% CI	n	M	95% CI	n
>6 but ≤24 months						
Without severe subnutrition	44.55	32.10 to 57.00	17	91.94	80.91 to 102.87	16
With severe subnutrition	44.87	37.25 to 52.49	30	98.56	92.52 to 104.61	32
>24 but ≤42 months						
Without severe subnutrition	40.06	32.27 to 47.86	11	98.08	80.86 to 115.31	12
With severe subnutrition	38.73	32.83 to 44.62	23	82.04	72.39 to 91.70	23

Note. Severe subnutrition was defined as weight 1.5 *SD*s below United Kingdom (UK) population norms at the time of entry into the UK. A repeated measures analysis of variance indicated a significant effect of time, $F(1, 73) = 384.75$, $p < .001$. There were nonsignificant trends for group, $F(3, 73) = 2.17$, $p = .10$, and for the interaction, $F(3, 73) = 2.29$, $p = .09$. The possible interaction reflected a significant difference among groups at age 6 but not at entry. R–PDQ = Revised Denver Prescreening Developmental Questionnaire; GCI = general cognitive index of the McCarthy Scales of Children's Abilities; CI = confidence interval.

lations between the GCI at age 6 and head circumference at UK entry and at age 6 were almost identical (.27 and .31, respectively, for those without subnutrition and .26 and .31, respectively, for those with subnutrition).

Although the group of adopting parents as a whole (both of Romanian children and within-UK children) had educational and occupational levels above those for general population norms, there was a meaningful spread. In order to determine the effects of parental educational level on children's cognitive functioning, we subdivided the parents' educational backgrounds into four groups: (a) a university degree or equivalent professional qualification; (b) superior scholastic achievement as reflected in successful exam performance at age 18 (advanced levels) or at least 5 good passes at age 16; (c) lower levels of exam performance at age 16; and (d) leaving school without scholastic credentials. Table 4 shows the mean GCI score of the children at age 6 across these four groups in relation to the father's educational level and, separately, the mother's educational level. There was no significant association either when assessed categorically (as shown in Table 4) or in terms of correlations when treating educational attainment in dimensional terms.

Gender differences were examined for all of the dependent variables considered in this article. No statistically significant main effects or interactions were found.

Disinhibited Attachment Patterns at Age 6

As already noted, the pattern of disinhibited attachment not only was much commoner in the adoptees from Romanian institutions but was also strongly associated with the duration of institutional deprivation. There was, however, the same issue as for cognitive impairment of needing to check whether this association could have been an artifact of the period of time in the adoptive home. Findings showed that it was not. The proportion of children showing disinhibited attachment was examined within the Romanian adoptees, all of whom had spent 2½ to 4 years in the adoptive home but who varied in the duration of their exposure to institutional rearing. Of those whose institutional care lasted less than 18 months, the rate of disinhibited attachment was 16% (13/84), compared with 33% (15/45) in those whose institutional care lasted between 24 and 42 months, $\chi^2(1, N = 129) = 5.50, p < .02$.

In contrast to the findings for cognitive impairment, there was no association between disinhibited attachment and head circumference either at the time of entry into the UK or at age 6 in the total sample of 144 institutionalized children. Head circumference, both at the time of UK entry and at age 6, did not differ substantially or significantly for those with versus those without disinhibited attachment: at UK entry, $M = -2.85$, 95% CI = –3.38 to –2.32, $n = 28$ versus $M = -2.50$, 95% CI = –2.84 to –2.15, $n = 28$, respectively, $F(1, 130) = 0.98, p = .33$; at age 6, $M = -1.75$, 95% CI = –2.10 to –1.39, $n = 31$ versus $M = -1.61$, 95% CI = -1.83 to –1.39, $n = 104$, respectively, $F(1, 133) = 0.38, p = .54$. Unlike the situation with cognition, there was no effect of subnutrition on disinhibited attachment. Weight at the time of UK entry and at 6 years did not differ significantly for those with versus those without disinhibited attachment at age 6: at UK entry, $M = -3.05$, 95% CI = -4.17 to –1.93, $n = 27$ versus $M = -2.28$, 95% CI = -2.65 to -1.91, $n = 103$, respectively, $F(1, 128) = 2.81, p = .10$; at age 6, $M = -0.61$, 95% CI = -0.99 to -0.22, $n = 31$ versus $M = -0.34$, 95% CI = -0.52 to -0.16, $n = 105$, respectively, $F(1, 134) = 1.80, p = .18$.

In order to test the hypothesis that attachment disinhibition might be a function of cognitive/affective processing, we compared children whose mental age, as assessed on the R–PDQ, was below 12 months at the time of UK entry with children whose mental age was higher. In almost all cases, even in the higher mental age group, the mental age was below 2 years, there being only 2 children whose levels were slightly above that. No significant association was found between mental age and attachment disinhibition; the proportions with disinhibition were 29.5% (23/78) for those with a mental age under 12 months at UK entry and 28.6% (4/14) for those with a higher mental age. The lack of difference still applied when comparisons were made among those with more than 6 but less than 24 months of institutional care (23.9% [11/46] vs. 25% [1/4]) or among those with more than 24 months of institutional care (37.5% [12/32] vs. 30.0% [3/10]). The lack of association between mental age and attachment disinhibition applied similarly when mental age was treated as a dimension and when cutoffs below or above 12 months were used.

Gender differences were also examined. Again, no statistically significant main effects or interactions were found.

Table 4
Educational Level of Adoptive Fathers and Mothers and General Cognitive Index at 6 Years of Romanian Adoptees

General Cognitive Index at age 6	Educational level of adoptive parents			
	Low	Moderate	High	Very high
Fathers				
M	103.6	97.9	103.5	99.5
95% CI	95.1–112.1	87.2–108.7	96.7–110.3	95.7–103.4
Mothers				
M	105.2	92.9	99.6	102.2
95% CI	96.9–113.6	83.9–101.8	92.6–106.6	94.6–109.7

Comparison of Correlates With Cognitive Impairment and With Disinhibited Attachment

As already stated, whereas both head circumference and subnutrition correlated with cognitive impairment, neither correlated with disinhibited attachment. Treated dimensionally, the Pearson correlations for the GCI were .29 and .24 for head circumference and weight at entry, respectively, compared with −.09 and −.16 in relation to the disinhibited attachment scores at age 6. In both cases, the correlations for the two outcome measures differed significantly when Steiger's (1980) method for comparing dependent correlations was used: $t(110) = 2.66$, $p < .05$ for correlations with head circumference, and $t(110) = 2.33$, $p < .05$ for correlations with weight ($n = 113$ in both instances).

Stability of Patterns Between 4 and 6 Years of Age

The hypothesis involving programming predicts at least moderate stability in adverse sequelae between ages 4 and 6. The findings are summarized in Table 5. With respect to both cognitive impairment and disinhibited behavior, there was substantial stability. The proportion of children showing these patterns remained much the same, individual differences across this 2-year time span were moderately stable, and the association with duration of deprivation was just about as strong at age 6 as it had been at age 4. Thus, the correlation between the GCI and the duration of institutional care was −.54 at 4 years and −.48 ($n = 91$) at 6 years (in both cases, $p < .01$). The Pearson correlation between attachment disinhibition and duration of institutional care was .22 ($p < .05$) at age 4 and .25 ($p < .05$) at age 6.

Heterogeneity in Outcome

As is implicit in the findings already reported here, there was substantial heterogeneity in outcome even for the children who had spent at least 2 years in profoundly depriving Romanian institutions. Even with this relatively late-adopted group, the IQ levels spanned the range from mental retardation to superior, with most children having GCI scores at 6 years somewhere in the range

Table 5
Stability of Effects on Cognitive Impairment and Attachment Disinhibition

Measure of stability	Cognitive impairment	Attachment disinhibition
Showing impairment at age 6 given impairment at age 4		
M	6/14	11/18
%	43	61
Odds ratio	67.00*	16.16*
Agreement on categorical distinctions between ages 4 and 6 (phi)	.56*	.57*

Note. Because children over the age of 2 years at the time of United Kingdom (UK) entry were already too old to be assessed at age 4, this table is based on children who came to the UK when they were younger than 2 years of age. The denominators in the first row concern only those showing impairment at age 4 years; accordingly, the numbers are much lower than those for the total sample of children experiencing institutional care.
* $p < .01$.

between the two extremes. Figure 1 shows the scattergram for the GCI scores at age 6 for the total sample of 144 institutional children (data were available on 136). There was no narrowing of the spread even in those with the longest duration of institutional deprivation. Exactly the same pattern was found with respect to disinhibited attachment although the rate was relatively high in the late-adopted children, two thirds of whom did *not* show this pattern (see O'Connor, Rutter, & the English and Romanian Adoptees Study Team, 2000).

Discussion

Differentiating Among Available Models of Early Experience Effects

The findings on cognitive impairment were reasonably clearcut. There was a strong association with institutional deprivation and, within the group of adoptees from Romanian institutions, there was a strong association with the length of institutional deprivation. With respect to outcome, two findings stand out. First, there was a remarkable degree of recovery after restoration of normal family rearing. Second, however, substantial deficits persisted after the children were placed in generally well-functioning adoptive families. Moreover, the deficits were quite marked. Thus, the mean GCI at age 6 was some 25–26 points lower in the children leaving institutions after the age of 2 years than in those who entered the UK before the age of 6 months. It is noteworthy that this effect was found to a similar degree even within the group who did not suffer substantial subnutrition. The developmental catch-up in head circumference was less than that found for weight, and cognitive impairment was particularly likely in those whose head circumferences remained substantially below population norms. It is also noteworthy that the duration of institutional deprivation was by far the strongest predictive factor for cognitive outcome, but, particularly in those who spent the longest time in depriving institutions, there was some effect from subnutrition.

By sharp contrast, cognitive functioning was unassociated with the length of time in the adoptive home after the first 2 to 2½ years, during which time the major developmental catch-up occurred. Also, the children's level of cognitive functioning at age 6 was completely unassociated with the educational level of either the adoptive mother or the adoptive father. This negative finding is particularly striking in view of the strong effect of educational attainment of adoptive parents in the Duyme, Dumaret, and Tomkiewicz (1999) study of a less seriously deprived sample.

The lack of any association between the GCI score at 6 years and the educational level of the adoptive parents, together with the strong association with duration of depriving institutional rearing even after taking into account the span of time in the adoptive home, makes any continuing psychosocial adversity explanation for the cognitive deficits found in some children implausible. Of course, it is possible that more detailed measures of parent–child interaction and communication might show an effect, but our findings do not support that suggestion (Croft et al., 2001). Specifically, observational measures of parent–child interactions at ages 4 and 6 indicated that an increase in the child's cognitive index predicted a positive change over time in the parents' interactional style, but there was no evidence of a reverse effect (Croft et al., 2001). That is, parent–child interaction at age 4 did not
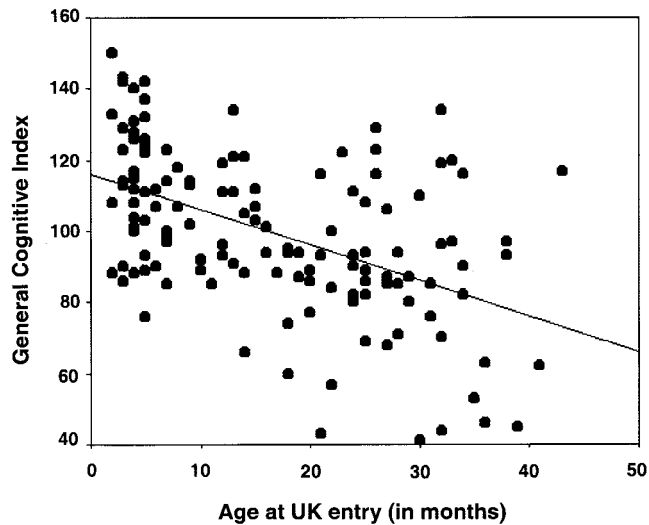
Figure 1. Scattergram and regression line for the association between cognitive level and age at entry into the United Kingdom (UK).

predict a positive change in the child's cognitive level between 4 and 6 years. Thus, none of the three available indices of the adoptive home environment (time in the adoptive home, parental educational level, or observational pattern of parent–child interaction) was predictive of the wide variation in children's cognitive scores at age 6.

In summary, the lack of association with conditions of rearing in the adoptive home, and the stability of the duration-of-deprivation effect across the age period from 4 to 6 years, suggests some form of programming effect or neural damage. The moderate association with head circumference (which was not dependent on general physical development, as indexed by weight gain) makes either experience-expectant programming or neural damage the most plausible of the available models.

The patterns of findings on disinhibited attachment were both very similar in some respects and rather different in others. They were the same in showing a substantial association with institutional deprivation and, within the institutionally deprived group, with duration of deprivation. There was considerable recovery of normal social functioning after provision of normal family rearing, and the majority of the relatively late-adopted children did not show disinhibited attachment. Nevertheless, the pattern of disinhibited attachment did persist after restoration of normal family rearing in a significant minority of the children. What was different from the findings with cognitive impairment was that there was no association with small head circumference and no association with subnutrition. It was also noteworthy that although the disinhibited attachment pattern was clearly highly discrepant from that normally found in well-functioning children, it did not show the usual features of insecure attachment. Rather, the details, both as observed and as reported by parents, suggested a relative failure to develop selective attachments rather than the acquisition of attachments that were insecure in quality.

As with cognitive impairment, the findings run counter to a continuing psychosocial adversity explanation. The association between duration of institutional care and disinhibited attachment

at 6 years was as strong as that at 4 years; there was no association with any occupational or educational measure of the adoptive parents; and there was moderately strong stability in the behavioral pattern between 4 and 6 years of age. Little is known about the family qualities that predispose children to disinhibited attachment (other than early institutional care). Accordingly, it is possible that unmeasured aspects of family interaction could have had an effect, but there was no indication that this might be so. Although not reported here, the observational measures of parent–child interaction used by Croft et al. (2001) showed no association with disinhibited attachment.

The lack of association between disinhibited attachment and the children's mental age at the time of UK entry also casts doubt on a cognitive processing explanation. It is implausible that children with a mental age of less than 12 months could remember specific experiences in infancy several years later, and it is also unlikely that any cognitive set established at that age would still be operative at age 6, especially after a major change in the rearing environment (see Kobak, 1999; Thompson, 1998). However, given that it is not known how cognitive sets or models are either established or retrieved, it is not possible to rule out their operation completely. Neural damage, too, does not seem a likely cause in view of the lack of association between disinhibited attachment and head circumference and in view of the lack of any effect of subnutrition. Rather, some form of developmental programming seems the most plausible explanation.

With both cognitive impairment and disinhibited attachment, there was a significant degree of stability in level between the ages of 4 and 6 years, as well as moderate consistency in individual differences. The findings clearly do not imply that there cannot be later recovery (the follow-up at ages 11–12 that is currently under way should cast light on that issue), but they do suggest that the patterns persist for at least 2 years after children leave the depriving institutional environment.

Limitations of Existing Models

The starting point for any discussion of models for the causal mechanisms involved in the sequelae of severe early institutional deprivation is the combination of three features: marked recovery following removal from the depriving environment, major deficits in a substantial minority that persist for at least 2½ years after rearing in a good family environment, and considerable individual differences in outcome. The implications for notions of developmental biological programming are provocative because the results both confirm and challenge the postulates of programming as put forward in a hard form. That is because programming concepts (whether experience-expectant or experience-adaptive) suppose that the effects will be universal, even if they vary in degree, and persistent even after good rearing conditions are provided if such provision occurs only after the end of the relevant sensitive period. The concepts also require the existence of a sensitive period during which biological development is shaped by relevant experiences.

The major degree of recovery found in children suffering profound institutional deprivation for 2 to 3½ years shows that the effects were far from fixed and irreversible. To the contrary, there was a remarkable degree of recovery following removal from the institutional environment, and the outcomes were surprisingly heterogeneous. Even within the subgroup of children whose insti-

tutional deprivation lasted until after 2 years of age, the majority did *not* show substantial cognitive impairment (a few even showed superior cognitive functioning), and most did *not* show disinhibited attachment. Accordingly, the findings run counter to any programming concept that presupposes universal and irreversible effects. Either the limited variations within the severe institutional deprivation range mean that some individuals received sufficient relevant experiences for normal or near-normal brain development to take place, or neural plasticity after the age of 2 years is enough to allow functional recovery to take place.

On the other hand, the major persisting deficits in many children also indicate that there were lasting changes in the organism that continued long after normal high-quality family rearing was provided. We thought perhaps that significant deficits would be found only if the deprivation continued for at least 2–3 years. Our results, however, contradict that expectation. To the contrary, the deficits began to be evident after institutional deprivation lasting for a period as short as 1 year (that is to say, they were evident in the group whose deprivation extended from 6 months up to 24 months). Detailed examination of the trends showed no indication of a threshold effect either during this age period or later. In short, the persistence of deficits requires some mechanism for the carry-forward of the effects of severe early institutional deprivation despite the radical change to a generally good rearing environment in a family context. Also, however, the occurrence of deficits in children who entered adoptive families well before 2 years of age implies that, if there is a sensitive period, it must begin to tail off by that age. On the other hand, the recovery findings imply that even if the tail-off begins early, it must continue for much longer.

With respect to cognitive impairment, the associations with subnutrition (albeit weaker than those with duration of institutional deprivation) and with a small head circumference both point to the likelihood of abnormal brain development (because it is brain growth that largely determines head size). The main alternatives, therefore, are positive neural damage (such as that found in rodents from high levels of stress on the hippocampus) or negative effects of a lack of experiences on normal brain development. In both cases, there is a neural basis; the difference lies between the active effects of noxious stimuli and the passive effects of a lack of experiences. The latter alternative definitely requires a sensitive period, whereas the former may or may not. Both imply, however, a mechanism that is distinct from the effects of variations in cognitive experiences on function at any age. There is, so far as is known, no sensitive period for the effects of experiences on cognitive function, but there may be one for those neural effects of experiences outside the normal range. Our data do not allow us to differentiate between active and passive mechanisms. However, experience-adaptive programming seems implausible because there is no reason to expect that this would be associated with impaired brain growth and because it seems unlikely that poor cognitive functioning would be adaptive even in a depriving institutional environment. Moreover, other research shows that the consequences do not derive from institutional rearing per se. Neither of the two British studies of children in residential group care (Hodges & Tizard, 1989a; Roy, Rutter, & Pickles, 2000) showed a significant effect on cognitive functioning. It may be concluded that institutional rearing as such has no necessary adverse effects on cognitive development. Rather, the ill effects seem to derive from the combination of institutional rearing and unusu-

ally severe and pervasive restriction of human interactions, play, conversation, and experiences. This gross pervasive deprivation seems to fall outside the range of expectable environments required for normal development.

The inferences with respect to disinhibited attachment are rather different. The lack of associations with head circumference and subnutrition suggest that there are no grounds for implicating active neural damage. Although the evidential base is weak, there is more reason than with cognitive development to infer a possible sensitive period. It is well established that young children ordinarily develop their first selective attachments between about 6 and 12 months of age, and clearly this has to be based on social interactions (Cassidy & Shaver, 1999). From the outset (Bowlby, 1969), attachment theory has postulated that there is a sensitive period for this development and that institutional care by rotating caregivers provides a poor source for the necessary experiences. Roy, Rutter, and Pickles (in press) found that impaired selective attachments were a feature of children reared in institutions and not of children from similarly deprived backgrounds who were reared in foster families. Wolkind (1974) showed that indiscriminate friendliness (a behavior related to disinhibited attachment) was evident in children admitted to institutions in infancy but not in those whose institutional care only began in middle childhood. Hodges and Tizard (1989b) found that the social deficits associated with early residential care persisted into adolescence even after years of rearing in a family environment.

The alternative explanations lie between the two forms of programming and some quite different mechanism that could account for the degree of persistence despite a radical change in environment. Some sort of sensitive period seems likely to be operative, but studies of selective attachments in children who experience institutional care only in middle childhood or later are much needed to test the possibility. Unlike the situation with cognitive impairment, disinhibited attachment seems to derive from some aspect of institutional care as such, without the need for gross pervasive experiential deprivation. That is because impaired social relationships (measured in rather diverse ways) have been found in children in relatively well-functioning residential group homes. What stood out as distinctive in these group homes was the lack of personalized caregiving, and it may well be that that is the key feature that puts children's social development at risk.

Experience-expectant programming carries the implication that an institutional environment, even one not associated with gross experiential restriction, falls outside the range of expectable environments required for normal brain development with respect to the neural systems underlying selective social relationships. That is quite possibly the case, but if the analogy with binocular vision is at all appropriate, there would seem to be an expectation that later compensatory social experiences might be of little benefit. Also, insofar as such experiences could be remedial, they would probably need to be of a kind similar to those thought to shape early selective attachments and the brain systems that underpin them.

Experience-adaptive programming carries the very different implication that, in some sense, disinhibited attachment may be adaptive in an institutional environment even if it is clearly maladaptive in an adoptive home. At first sight, that seems implausible because the essential feature of early attachments concerns their selectivity and the sense of security that they provide. Possibly, in an institutional environment with a lack of personalized caregiving

and a very large number of rotating caregivers, it could be adaptive to seek interactions in a nonselective way in order to make some sort of relationship with the caregivers who come and go. The possibility warrants further study because, if valid, it implies that, rather than moving swiftly into selective intimate relationships in the adoptive family, a more gradual transition may be preferable.

If both forms of programming are rejected as explanations, some alternative mechanism for the carryforward of effects must be postulated. If it is not to involve some type of persisting neural change that is resistant to the effects of later environments (the hallmark of the programming concept), it is most likely to involve the effects on other people of the young children's behavior. There is no doubt that children do indeed have effects on those with whom they interact (Bell, 1968; Bell & Chapman, 1986; Rutter et al., 1997; Rutter & Silberg, 2002), and this could lead to persistence of sequelae. However, neither our quantitative findings nor our qualitative observations suggested that these effects (though clearly they were present) accounted for the persistence of disinhibited attachment. On the other hand, this explanation could not be ruled out.

Individual Differences and Implications for Resilience

Individual differences in both cognitive and social functioning were great even in those who had experienced the longest periods of institutional deprivation. In itself, the occurrence of wide individual variations is unremarkable. After all, there is every reason to suppose that the children differed in their genetic backgrounds and that this is likely to have had effects on their cognition and social relationships. It is unlikely that their experiences before admission to the institutions would have had much impact because, in almost all cases, these lasted only a very few weeks. On the other hand, there is likely to have been some variation in the children's experiences within the institutions (but within a range of very poor quality) and some variation in experiences within their adoptive homes (although, in this case, within a range of generally above-average environments). The surprising aspects of the individual differences were three: (a) the extent of the variations given the extraordinarily severe deprivation in the institutions, which might have been expected to wipe out other influences; (b) the substantial minority of children who experienced the most prolonged deprivation but yet showed no measurable deficits; and (c) the relative frequency of normality (or near-normality) given the expectations of the programming concepts.

Do these findings mean that we should reject the programming concept in relation to our findings? Not necessarily given the other indications of its possible relevance—but, if accepted, it does imply that programming effects may be less absolute and less fixed than commonly supposed. However, if that is accepted, it leaves open the question of what influences brought about the individual differences. Do they stem from influences (perhaps genetic) unconnected with the institutional deprivation? Or do they reflect variations in the degree of institutional deprivation or differences in the ways in which the children responded to their experiences (possibly as a result of gene–environment interactions)? Alternatively, do they derive from variations in the adoptive home environments? Clearly, our present data set provides no answers on these important questions, but the just-completed follow-up at age 11 may be informative.

Research Implications

A range of different research strategies are required to answer the questions we have raised. Structural brain imaging could be informative with respect to the variations in head circumference. Functional brain imaging should be helpful in determining whether the brain systems underlying social processing in these children are at all unusual. Follow-up data in adolescence will provide better leverage on the extent to which deficits persist, revert, or change and on the environmental factors operating in middle childhood that influence these features. Intervention studies will be needed to provide systematic information on the factors that influence persistence and desistance in behavioral patterns.

Limitations of the Data Set

Our findings are based on a group of children who suffered a degree of institutional deprivation far beyond that ordinarily seen in modern industrialized societies. Inevitably, therefore, there must be considerable caution in extrapolating the findings to less extreme conditions of deprivation. Nevertheless, the findings raise important questions about the effects of early experiences on later development, effects that would seem likely to be mediated by some sort of effect on brain structure and function, although just what those are remains uncertain. Our findings cannot differentiate between the two broad forms of developmental programming that have been postulated, and we cannot rule out the possibility that there has been brain damage (rather than programming). Finally, it is important to emphasize that nothing is known about the neural substrate of developmental programming as it affects the brain—either with respect to cognitive impairment or disinhibited attachment.

Conclusion

Our research findings as a whole indicate that the effects of institutional rearing on IQ apply only when such rearing involves profound general deprivation. The association between IQ, subnutrition, and head circumference suggests that it is unlikely that the effects involve experience-adaptive programming; rather, experience-expectant programming or biological damage seems probable. By contrast, the effects of institutional rearing on attachment disinhibition seem to apply to institutional rearing even when profound deprivation is not involved. The lack of association with either subnutrition or head circumference makes brain damage a less plausible explanation. Either experience-expectant or experience-adaptive programming seems to be the most plausible explanation. The research challenge for the future is to determine what these effects mean in terms of their neural basis, and if that challenge is to be taken up successfully, it will certainly be necessary that the relevant psychosocial and developmental research be integrated with biology and with biological studies.

References

Bakshi, V. P., & Kalin, N. H. (2000). Corticotropin-releasing hormone and animal models of anxiety: Gene–environment interactions. *Biological Psychiatry, 48,* 1164–1174.

Barbazanges, A., Vallée, M., Mayo, W., Day, J., Simon, H., Le Moal, M., & Maccari, S. (1996). Early and later adoptions have different long-term

effects on male rat offspring. *The Journal of Neuroscience, 16,* 7783–7790.

Barker, D. J. (1997). Fetal nutrition and cardiovascular disease in later life. *British Medical Bulletin, 53,* 96–108.

Bateson, P. P. (1966). The characteristics and context of imprinting. *Biological Review, 41,* 177–211.

Bateson, P., & Martin, P. (1999). *Design for a life: How behaviour develops.* London: Jonathan Cape.

Bell, R. Q. (1968). A reinterpretation of the direction of effects in studies of socialization. *Psychological Review, 75,* 81–95.

Bell, R. Q., & Chapman, M. (1986). Child effects in studies using experimental or brief longitudinal approaches to socialization. *Developmental Psychology, 22,* 595–603.

Blakemore, C. (1991). Sensitive and vulnerable periods in the development of the visual system. In G. R. Bock & J. Whelan (Eds.), *The childhood environment and adult disease: Ciba Foundation Symposium 156* (pp. 129–146). Chichester, England: Wiley.

Bock, G. R., & Whelan, J. (Eds.). (1991). *The childhood environment and adult disease: Ciba Foundation Symposium 156.* Chichester, England: Wiley.

Bornstein, M. (1987). *Sensitive periods and development.* Hillsdale, NJ: Erlbaum.

Bowlby, J. (1951). *Maternal care and mental health.* Geneva: World Health Organization.

Bowlby, J. (1969). *Attachment and loss: Vol. 1. Attachment.* London: Hogarth Press.

Boyce, L., & Cole, T. (1993). Growth Programme (Version 1 & 2) [Computer software]. Ware, England: Castlemead.

Bremner, J. D. (1999). Does stress damage the brain? *Biological Psychiatry, 45,* 797–805.

Bretherton, I., & Mulholland, K. A. (1999). Internal working models in attachment relationships: A construct revisited. In J. Cassidy & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research and critical applications* (pp. 89–111). New York: Guilford Press.

Bruce, D., Dolan, A., & Phillips-Grant, K. (2000). On the transition from childhood amnesia to the recall of personal memories. *Psychological Science, 11,* 360–364.

Bruer, J. T. (1999). *The myth of the first three years.* New York: Free Press.

Buckler, J. (1990). *A longitudinal study of adolescent growth.* London: Springer-Verlag.

Caldji, C., Diorio, J., & Meaney, M. J. (2000). Variations in maternal care in infancy regulate the development of stress reactivity. *Biological Psychiatry, 48,* 1164–1174.

Cassidy, J., & Shaver, P. R. (1999). *Handbook of attachment: Theory, research and clinical applications.* New York: Guilford Press.

Castle, J., Groothues, C., Bredenkamp, D., Beckett, C., O'Connor, T. G., Rutter, M., & the E.R.A. Study Team (1999). Effects of qualities of early institutional care on cognitive attainment. *American Journal of Orthopsychiatry, 69,* 424–437.

Clarke, A. M., & Clarke, A. D. B. (1976). *Early experience: Myth and evidence.* London: Open Books.

Clarke, A. M., & Clarke, A. D. B. (2000). *Early experience and the life path.* London: Jessica Kingsley.

Croft, C., O'Connor, T., Keaveney, L., Groothues, C., Rutter, M., & the English and Romanian Adoption Study Team. (2001). Longitudinal change in parenting associated with developmental delay and catch-up. *Journal of Child Psychology and Psychiatry, 42,* 649–659.

Dodge, K. A., Pettit, G. S., Bates, J. E., & Valente, E. (1995). Social information-processing patterns partially mediate the effects of early physical abuse on later conduct problems. *Journal of Abnormal Psychology, 104,* 632–643.

Duyme, M., Dumaret, A.-C., & Tomkiewicz, S. (1999). How can we boost IQs of "dull children"? A late adoption study. *Proceedings of the National Academy of Sciences, USA, 96,* 8790–8794.

Farrington, D. P., & Loeber, R. (2000). Some benefits of dichotomization in psychiatric and criminological research. *Criminal Behaviour and Mental Health, 10,* 100–122.

Francis, D., Diorio, J., Liu, D., & Meaney, M. J. (1999). Nongenomic transmission across generations of maternal behavior and stress response in the rat. *Science, 286,* 1155–1158.

Frankenburg, W. K., van Doorninck, W. J., Liddell, T. N., & Dick, N. P. (1986). *Revised Denver Prescreening Developmental Questionnaire (R-PDQ).* High Wycombe, England: DDM Inc./The Test Agency Ltd.

Greenough, W. T., Black, J. E., & Wallace, C. S. (1987). Experience and brain development. *Child Development, 58,* 539–559.

Hennessey, J. W., & Levine, S. (1979). Stress, arousal, and the pituitary-adrenal system: A psychoendocrine hypothesis. In J. M. Sprague & A. N. Epstein (Eds.), *Progress in psychobiology and physiological psychology* (pp. 133–178). New York: Academic Press.

Hodges, J., & Tizard, B. (1989a). IQ and behavioural adjustment of ex-institutional adolescents. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 30,* 53–75.

Hodges, J., & Tizard, B. (1989b). Social and family relationships of ex-institutional adolescents. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 30,* 77–97.

Howe, M. L., & Courage, M. L. (1993). On resolving the enigma of infantile amnesia. *Psychological Bulletin, 113,* 305–326.

Hubel, D. H., & Wiesel, T. N. (1965). Binocular interaction in striate cortex of kittens reared with artificial squint. *Journal of Neurophysiology, 28,* 1041–1049.

Hubel, D. H., Wiesel, T. N., & Le Vay, S. (1977). Plasticity of ocular dominance columns in monkey striate cortex. *Philosophical Transactions of the Royal Society of London—Series B: Biological Sciences, 278,* 377–409.

Kagan, J. (1980). Perspectives on continuity. In O. G. Brim & J. Kagan (Eds.), *Constancy and change in human development* (pp. 26–74). Cambridge, MA: Harvard University Press.

Klaus, M. H., & Kennell, J. H. (1976). *Maternal–infant bonding: The impact of early separation or loss on family development.* St. Louis, MO: C. V. Mosby.

Kobak, R. (1999). The emotional dynamics of disruptions in attachment relationships: Implications for theory, research and clinical intervention. In J. Cassidy & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research and clinical applications* (pp. 21–43). New York: Guilford Press.

Kreppner, J., O'Connor, T. G., Dunn, J., Anderson-Wood, L., & the ERA Study Team (1999). The pretend and social role play of children exposed to severe early deprivation. *British Journal of Developmental Psychology, 17,* 319–332.

Kreppner, J., O'Connor, T. G., Rutter, M., & the E. R. A. Study Team (2001). Can inattention/overactivity be an institutional deprivation disorder? *Journal of Abnormal Child Psychology, 29,* 513–528.

Kuhl, P. K. (1994). Learning and representation in speech and language. *Current Opinion in Neurobiology, 4,* 812–822.

Kuhl, P. K., Andruski, J. E., Chistovich, I. A., Chistovich, L. A., Kozhevnikova, E. V., Ryskina, V. L., et al. (1997). Cross-language analysis of phonetic units in language addressed to infants. *Science, 277,* 684–686.

Le Grand, R., Mondloch, C., Maurer, D., & Brent, H. P. (2001). Neuroperception: Early visual experience and face processing. *Nature, 410,* 890.

Lien, N. M., Meyer, K. K., & Winick, M. (1977). Early malnutrition and "late" adoption: A study of their effects on development of Korean orphans adopted into American families. *American Journal of Clinical Nutrition, 30,* 1734–1739.

Maccari, S., Piazza, P. V., Kabbaj, M., Barbazanges, A., Simon, H., & Le Moal, M. (1995). Adoption reverses the long-term impairment in glucocorticoid feedback induced by prenatal stress. *Journal of Neuroscience, 15,* 110–116.

Main, M., Kaplan, N., & Cassidy, J. (1985). Security in infancy, childhood and adulthood: A move to the level of representation. In I. Bretherton & E. Waters (Eds.), Growing points in attachment theory and research (pp. 66–106). *Monographs of the Society for Research in Child Development, 50*(1–2, Serial No. 209).

McCarthy, D. (1972). *The McCarthy Scales of Children's Abilities.* New York: Psychological Corporation/Harcourt Brace Jovanovich.

McEwen, B. S. (1999). The effects of stress on structural and functional plasticity in the hippocampus. In D. S. Charney, E. J. Nestler, & B. S. Bunney (Eds.), *Neurobiology of mental illness* (pp. 475–493). New York: Oxford University Press.

O'Brien, P. M. S., Wheeler, T., & Barker, D. J. P. (Eds.). (1999). *Fetal programming: Influences on development and disease in later life.* London: RCOG Press.

O'Connor, T. G., Bredenkamp, D., Rutter, M., and the English and Romanian Adoptees (ERA) Study Team. (1999). Attachment disturbances and disorders in children exposed to early severe deprivation. *Infant Mental Health Journal, 20,* 10–29.

O'Connor, T. G., Marvin, R. S., Rutter, M., Olrick, J., Britner, P. A., & the E. R. A. Study Team. (2003). Child–parent attachment following severe early institutional deprivation. *Development and Psychopathology, 15,* 19–38.

O'Connor, T. G., Rutter, M., Beckett, C., Keaveney, L., Kreppner, J. M., & the English and Romanian Adoptees (ERA) Study Team. (2000). The effects of global severe privation on cognitive competence: Extension and longitudinal follow-up. *Child Development, 71,* 376–390.

O'Connor, T. G., Rutter, M., & the English and Romanian Adoptees Study Team. (2000). Attachment disorder behavior following early severe deprivation: Extension and longitudinal follow-up. *Journal of the American Academy of Child and Adolescent Psychiatry, 39,* 703–712.

Pawlby, S. J., Mills, A., & Quinton, D. (1997). Vulnerable adolescent girls: Opposite sex relationships. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 38,* 909–920.

Pawlby, S. J., Mills, A., Taylor, A., & Quinton, D. (1997). Adolescent friendships mediating childhood adversity and adult outcome. *Journal of Adolescence, 20,* 633–644.

Pilling, D., & Kellmer-Pringle, M. (1978). *Controversial issues in child development.* London: Elek Books.

Quinton, D., Pickles, A., Maughan, B., & Rutter, M. (1993). Partners, peers, and pathways: Assortative pairing and continuities in conduct disorder. *Development and Psychopathology 5,* 763–783.

Quinton, D., & Rutter, M. (1988). *Parenting breakdown: The making and breaking of intergenerational links.* Aldershot, England: Avebury.

Roy, P., Rutter, M., & Pickles, A. (2000). Institutional care: Risk from family background or pattern of rearing? *Journal of Child Psychology and Psychiatry and Allied Disciplines, 41,* 139–149.

Roy, P., Rutter, M., & Pickles, A. (in press). Institutional care: Associations between overactivity and a lack of selectivity in attachment relationships. *Journal of Child Psychology and Psychiatry and Allied Disciplines.*

Rutter, M. (1981). *Maternal deprivation reassessed* (2nd ed.). Harmondsworth, Middlesex, England: Penguin Books.

Rutter, M. (1985a). Family and school influences on behavioural development. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 26,* 349–368.

Rutter, M. (1985b). Family and school influences on cognitive development. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 26,* 683–704.

Rutter, M. (1989). Pathways from childhood to adult life. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 30,* 23–51.

Rutter, M. (2000). Psychosocial influences: Critiques, findings, and research needs. *Development and Psychopathology, 12,* 375–405.

Rutter, M. (2002a). Maternal deprivation. In M. Bornstein (Ed.), *Handbook of parenting* (2nd ed., pp. 181–202). Mahwah, NJ: Erlbaum.

Rutter, M. (2002b). Nature, nurture and development: From evangelism through science towards policy and practice. *Child Development, 73,* 1–21.

Rutter, M., Anderson-Wood, L., Beckett, C., Bredenkamp, D., Castle, J., Groothues, C., Kreppner, J., Keaveney, L., Lord, C., O'Connor, T. G., & the E. R. A. Study Team. (1999). Quasi-autistic patterns following severe early global privation. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 40,* 537–549.

Rutter, M., Dunn, J., Plomin, R., Simonoff, E., Pickles, A., Maughan, B., et al. (1997). Integrating nature and nurture: Implications of person–environment correlations and interactions for developmental psychopathology. *Development and Psychopathology, 9,* 335–366.

Rutter, M., & the ERA Research Team. (1998). Developmental catch-up and deficit following adoption after severe global early privation. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 39,* 465–476.

Rutter, M., Kreppner, J. K., O'Connor, T. G., & the ERA Study Team. (2001). Specificity and heterogeneity in children's responses to profound privation. *British Journal of Psychiatry, 179,* 97–103.

Rutter, M., Maughan, B., Pickles, A., & Simonoff, E. (1998). Retrospective recall recalled. In R. B. Cairns, L. R. Bergman, & J. Kagan (Eds.), *Methods and models for studying the individual* (pp. 219–242). Thousand Oaks, CA: Sage.

Rutter, M., Pickles, A., Murray, R., & Eaves, L. (2001). Testing hypotheses on specific environmental causal effects on behavior. *Psychological Bulletin, 127,* 291–324.

Rutter, M., & Robins, L. (Eds.). (1990). *Straight and devious pathways from childhood to adulthood.* New York: Cambridge University Press.

Rutter, M., & Silberg, J. (2002). Gene–environment interplay in relation to emotional and behavioral disturbance. *Annual Review of Psychology, 53,* 463–490.

Sackett, G. P. (1965). Effects of rearing conditions upon the behavior of rhesus monkeys (*Macaca Mulatta*). *Child Development, 36,* 855–868.

Schneider, M. L., & Moore, C. F. (2000). Effect of prenatal stress on development: A nonhuman primate model. In C. A. Nelson (Ed.), *Minnesota Symposium on Child Psychology: Vol. 31. The effects of early adversity on behavioural development* (pp. 201–244). Mahwah, NJ: Erlbaum.

Sluckin, W. (1973). *Imprinting and early learning* (2nd ed.). Chicago: Aldine.

Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological Bulletin, 87,* 245–251.

Teasdale, J. D., & Barnard, P. J. (1993). *Affect, cognition, and change: Re-modelling depressive thought.* Hove, England: Erlbaum.

Thompson, R. A. (1998). Early sociopersonality development. In W. Damon (Series Ed.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (5th ed., pp. 25–104). New York: Wiley.

Wolkind, S. N. (1974). The components of "affectionless psychopathology" in institutionalized children. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 15,* 215–220.

World Health Organization Expert Committee on Mental Health. (1951). *Report on the second session, 1951.* Geneva: World Health Organization.