Evolution and Human Behavior 29 (2008) 249–255

Contingent parental investment: an evolutionary framework for understanding early interaction between mothers and children

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Initial receipt 16 August 2007; final revision received 7 January 2008

Abstract

Evolutionary psychology predicts that mothers invest differentially in their children as a function of (a) cues to the child's reproductive value and (b) their own access to caregiving resources. In contrast to the traditional additive model of these effects, a contingent model was tested in which high-risk offspring were expected to receive either *more* or *less* investment than low risk offspring—based on maternal resources. In a prospective test of this model, we measured children's premature status at birth as a cue to their reproductive risk and mother's postpartum depressive symptoms as an indicator of depleted attentional, emotional, and cognitive resources. As predicted, (1) mothers with low resources showed greater investment in low-risk than high-risk children, and (2) mothers with higher resources showed greater investment in high-risk than low-risk children. In addition, older primiparous mothers (in contrast with younger mothers or multiparous older mothers) manifested high investment in high-risk children. No reliable support was found for the Trivers–Willard hypothesis.

Keywords: Parental investment; Maternal depression; Premature infants

1. Parental investment: an evolutionary framework for understanding early interaction between mothers and children

Trivers (1974) proposed that parental investment represents a zero-sum allocation of resources to the young. Specifically, if parents invest in any one particular child, they have fewer resources available to invest in other existing or future offspring. Furthermore, it has been strongly suggested that two factors influence parental investment decisions: (1) child characteristics (or reproductive potential) and (2) parental access to resources that can be converted into parental investment.

Daly and Wilson (1984, 1988) provided actuarial evidence supporting these basic arguments. For example, they demonstrated that children with low reproductive potential are more likely to be neglected, maltreated, and are greater at risk for infanticide. In addition, parents who have low economic resources are more likely than those with high resources to show reduced investment in their children—as evidenced by their higher levels of child abuse and neglect (Garbarino, 1985).

1.1. A theoretical extension of parental investment theory

Bugental and Beaulieu (2003) extended parental investment theory by suggesting that the combined influence of parental resources and the child's reproductive potential involves a contingent rather than an additive pattern (see Fig. 1). The contingent model suggests an "if: then" decision-making process. If parents have low resources, there is agreement (across models) that parents will show low investment (e.g., high neglect) in a child with low reproductive potential. However, if parents have high resources, the contingency model (unlike the additive model) predicts that parents will preferentially invest in a child with *low* reproductive potential. If parents have high resources, they can afford to invest a greater amount of resources in their low reproductive potential child, while still having sufficient resources to provide for other children. As a result of this added investment, a high-risk child may be expected to survive to reproductive age, and thus their parents' reproductive success is potentially increased.

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doi:10.1016/j.evolhumbehav.2008.01.002

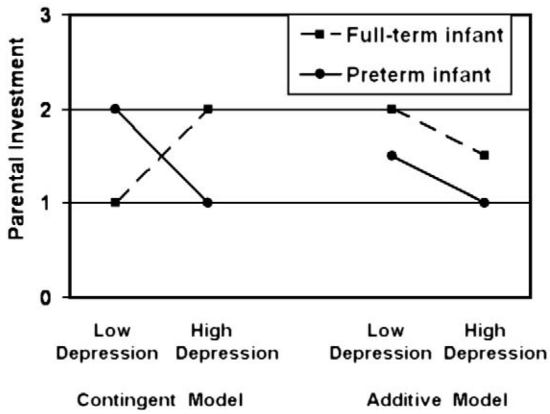

Fig. 1. Two models of parental investment (hypothetical findings).

1.2. Nonhuman evidence for the contingent model of parental investment

Davis and Todd (1999) demonstrated in a simulation study that nonhuman mothers (birds) are more likely to have the greatest reproductive success if they follow different strategies—based on the reproductive potential of the young and their own access to food resources. The question has also been addressed on the basis of actual observations of the behaviors shown by nonhumans. Maestripieri and Carroll (1998), in reviewing the relevant literature, concluded that nonhuman mothers have been shown to be sensitive to both the relative costs and benefits of offspring and the relative accessibility of provisions (food) within their current environment. In addition, some birds have been shown to follow these complex computational rules. That is, they shift their feeding strategies on the combined basis of the reproductive potential of the young and the availability of food (Gottlander, 1987). Thus, when resources are scarce, they feed the largest chick first but when resources are plentiful, they feed the smallest chick first. Similar processes have also been observed in nonhuman primates (e.g., Nakamichi, 1986).

1.3. Empirical evidence for predicted patterns in humans

Although a similar pattern has been proposed for human as for nonhumans (Mann, 1992), only suggestive evidence is currently available to support this contingent pattern of parental investment. At a societal level, parents in high-poverty areas are likely to show low investment in at-risk infants (e.g., Schepher-Hughes, 1985), whereas parents in more affluent areas (as is true in many part of the United States) are more likely to show exceptionally high investment in the same kinds of infants (e.g., very low-birth-weight infants). On an experimental level, Bugental and Beaulieu (2003) reported that mothers showed greater investment in high-risk than low-risk infants after their involvement in a home visitation program (providing cognitive-emotional resources), whereas a matched sample in a control condition showed the opposite response pattern. However, the measure of investment in this research (willingness to exert effort to obtain information about their children) was somewhat limited.

1.3.1. Present study

In the present investigation, we proposed a test of the two models of parental investment described above. Stronger support was predicted for the contingency rather than for the additive model. Although the focus within the parental investment literature has been on parents' physical resources, we suggest here that parents' personal resources, for example, their *attentional resources* to provide care for their offspring are of critical concern in early development. Depression has long been found to predict *slowed* interpersonal responses (e.g., Zlochower & Cohn, 1996) and general deficits in the availability of attentional resources (Hartlage, Alloy, Vazquez, & Dykman, 1993). As a reflection of this resource reduction, depressed mothers manifest relatively low levels of attention to their infants' needs and attention bids (e.g., Donovan, Leavitt, & Walsh, 1998; Mertesacker, Bade, Haverkock, & Pauli-Pott, 2004)—a deficit that has negative consequences for the young. Even short-term (experimentally produced) withdrawal of maternal attention produces stress in infants (e.g., Gianino & Tronick, 1988) and continued exposure to such processes leads to long-term dysregulation of stress response systems and behavior patterns (e.g., Adam, Klimes-Dougan, & Gunnar, 2007; Moore & Calkins, 2004). Parental access to and allocation of attentional resources is just as meaningful in parenting relationships as is access to and allocation of nutritional resources. For example, maternal depression has also been found to predict reduced infant weight gain (Hendrick, Smith, Hwang, Altshuler, & Haynes, 2003; Rahman, Iqbbal, Bunn, Lovel, & Harrington, 2004). Despite our focus here on attentional resources, an assessment was also made of the effects of other resource limitations (e.g., absence of the father in the home, and low maternal education).

Parental investment was measured here by (1) maternal preference for allocating resources to the child rather than the self and (2) computational processes consistent with protective care. The sample employed included a high representation of preterm children, a grouping of children that represents an example of offspring that in the distant human past had relatively low reproductive potential. Even in today's world, morbidity and mortality have been found to be higher for preterm than full-term children. For example, preterm status (currently accounting for 12% of US births) has been identified as the major predictor of early childhood mortality and neonatal mortality in the United States (Green et al., 2005). Premature status poses long-term as well as short-term reproductive costs by virtue of the fact that such children are at elevated risk for later medical problems (e.g., Picard, Del Dotto, & Breslau, 2000).

Predictions offered by others with respect to parental investment were tested in the current sample on an exploratory basis. For example, a test was made of the

Trivers–Willard model (Trivers & Willard, 1973)—in which it was predicted that mothers in "good condition" (e.g., healthy, strong) are more likely to invest in sons, whereas those in poor condition are more likely to invest in daughters—a strategy seen as maximizing reproductive success as a result of the disproportionate advantage of sons to benefit from high maternal condition. Evidence for this model has been mixed among nonhumans (Brown & Silk, 2002) and qualified (Koziel & Ulijaszek, 2001) or absent (e.g., Keller, Nesse, & Hofferth, 2001) among humans. In this study we employed maternal depression and (low) education as potential markers of poor maternal condition (Lovejoy, Graczyk, O'Hare, & Neuman, 2000).

A test was also made of the differential pattern of investment shown as a result of maternal age and parity—factors that may combine to increase parental investment. That is, increasing age may predict a particularly high investment level among primiparous mothers—a strategy proposed as maximizing their reproductive success in the face of reduced future opportunities for childbearing. This expectation has been supported empirically by Hagen (2002) who demonstrated that older mothers invest in their singleton infants even when faced with low infant viability and low social support.

Finally, a test was made of the differential pattern of investment shown to first-born vs. later-born children [testing predictions introduced by Suloway (1996) and followed up with later cross-national research (Rohde, 2003)]. Although our particular sample did not allow a test of investment patterns with middle-born children, it did allow a comparison of investment patterns shown in first-born vs. later-born children. Based on the work of Rohde et al., greater investment would be expected in later-born children.

2. Methods

2.1. Sample

The sample involved 60 mothers and children. The mean age of children at intake was 8.58 weeks (S.D.=5.75 weeks), and their mean age at follow-up testing was 20 months (S.D.=2 months). Families were participants within a child abuse prevention program and were originally recruited through referrals from medical professionals when the child was born. Acceptance rate (after hearing a full description of the program) was relatively high (77%). An additional 7% failed to complete the program. Thus, the full retention rate was 70%. All parents gave signed consent to participation (consent obtained separately for participation and for obtaining measures—using consent forms approved by the campus IRB). The sample included 56 Latina and 4 Anglo mothers (consistent with the ethnic distribution of participants in past studies within this program of research, Bugental et al., 2002). The mean age of mothers was 27 (S.D.=6), and the mean education of mothers was 9 years (S.D.=3). In 80% of the families, the biological father was married to the mother and living in the home. Thirty-eight percent of mothers were primiparous, and the mean number of siblings was .70 (S.D.=1.06).

Families were recruited with a particular focus on children with early medical problems. Within this sample, half of the children were identified as premature (defined here as a gestational age of 36 weeks or less). However, the parents of full-term vs. pre-term infants were equivalent in other ways. That is, no significant (or trend-level) correlations (Pearson r's) were found between the child's gestational age and the demographic characteristics of parents (maternal education, maternal age, or number of siblings). In addition, no significant differences (or trends) were found in the gestational age for boys vs. girls, for families that did or not include the father or that were Latino or Anglo. In past research within this program (Bugental & Happaney, 2004), (even mild) preterm status has been identified as a key predictor of later caregiving problems and is employed here as a marker of children's (low) reproductive potential.

2.2. Measures and procedure

2.2.1. Demographic variables

Demographic variables included: maternal education, maternal age, maternal ethnicity, marital status, number of children, and sex of child. Maternal education was highly skewed in this sample and measures were converted to log-transformed scores.

2.2.2. Birth history

The child's gestational age was obtained from hospital records.

2.2.3. Maternal depression

Maternal depression was included as a measure of attention resources (as well as an indicator of "maternal condition"). The Beck Depression Inventory (BDI) provides a commonly used measure of depressive symptoms, validated against clinical ratings of depression (Beck, Steer, & Garbin, 1988, 1996). These investigators have found that α coefficients measuring internal consistency range from .73 to .92.

2.2.4. Measures of parental investment

Two measures were taken of parental investment (at an 18-month visit): (1) a motivational measure and (2) a computational/perceptual measure. The first measure assessed the mother's motivation to obtain benefits for herself vs. her child. Mothers were shown 12 pictures of items available for purchase on the Internet. Half of the items were valuable to the mother herself (perfume bottle), and half were valuable for the child (educational toy). Mothers were asked to list their top three preferences for a gift to be brought to them at a later time. The items shown were equated for their approximate financial value. The key rating on this measure was the number of items in the top three choices that involved a gift for the infant vs. a gift for the mother (a zero-sum measure). Thus, a value of 3 would

Table 1
Motivation for parental investment

Step	Variable	B	S.E. (B)	β	R^2 change
Step 1					.01
	Participation in intervention	−0.21	0.25	−.11	
Step 2					.01
	Gestational age	−0.01	0.03	−.03	
	Level of depression (BDI)	0.01	0.01	.09	
Step 3					.07 *
	Gestational Age × Depression	0.01	0.00	.28 *	

* $p<.05$.

reflect the highest level of parental investment (all three choices involved gifts for the child) and a value of 0 would reflect the lowest level of parental investment (all three choices involving gifts for the mother) (Table 1).

A second measure assessed the mother's perceptual bias in estimating her child's height. Our specific interest was in assessing the extent to which mothers guessed their children to appear younger (i.e., shorter) or older (i.e., taller) than they actually were. Underestimation indicates high activation of the mother's caregiving computational system. That is, a bias reflecting the perception of the child as small suggests that she sees the child as young and in need of protective care. In contrast, a bias reflecting the perception of the child as taller than they are suggests reduced activation of the caregiving system [consistent with McCabe's (1984) finding that children who appeared older than their actual age were significantly more likely than other children to be maltreated].

2.2.5. Relationship between variables

No significant relationships (or trends) were found between dependent variables and maternal age, maternal education, maternal ethnicity, number of siblings, gender of child, or presence/absence of father in the home. Thus, none of these variables (as main effects) posed a significant challenge to central predictions.

2.2.6. Procedure

Demographic variables and the BDI were measured at the intake visit (typically during the first 3 months of the child's life). Parental investment measures were taken at an 18-month visit. All visits took place in the family's home.

3. Results

3.1. Analysis strategy

Predictions were tested by use of hierarchical regression analysis. The two parental investment measures (which are modestly correlated, Pearson $r=.26$, $p=.06$) represent the two dependent variables. Differential participation in one of two home visitation programs (to which participants had been randomly assigned) was included as a covariate at Step 1 in all regression analyses. The main effects of the two key independent variables (child gestational age and maternal scores on the BDI) were tested at Step 2 of the analysis. The predicted interaction was tested at Step 3 of the analysis. The specific *pattern* of interaction predicted was tested using methods suggested by Aiken and West (Aiken & West, 1991, West, Aiken & Krull, 1996). Follow-up analyses were also conducted to determine whether paternal absence or lack of maternal education posed resource limitations that led to effects equivalent to those expected for maternal depression.

A series of regression analyses was also conducted to test rival or additional predictions regarding parental investment. First, regression analyses were conducted to test the role of alternative maternal resources (maternal education and presence of father in the home) that might interact with child risk in predicting investment. Second, regression analyses were conducted to determine the interactive effects of maternal age and parity on her investment patterns. Third, regression analyses were conducted to provide a test of the Trivers–Willard hypothesis by assessing the differential investment shown in boys vs. girls as a combined effect of child gender and maternal condition (as assessed by either her education or presence of depressive symptoms). Finally, a multivariate analysis of variance (that included both investment measures as dependent variables) was conducted to test the effects of the child's birth order (first-born vs. later-born) on parental investment.

3.2. Test of central predictions

3.2.1. Motivational investment

The regression analysis testing the effects of maternal depression and child gestational age on motivational investment (i.e., greater allocation of resources to child than self) revealed the predicted interaction ($\beta=.28$, $p=.05$). The specific pattern of interaction (shown in Fig. 2) is consistent with the contingency model but not the additive model of parental investment. Follow-up regression analyses were conducted separately for children that were full-term (greater than 36 weeks in gestational age) and for children that were preterm (less than 36 weeks in gestational age). A significant effect was obtained for the effects of maternal depression for preterm children ($\beta=-.39$, $p=.05$). That is, the

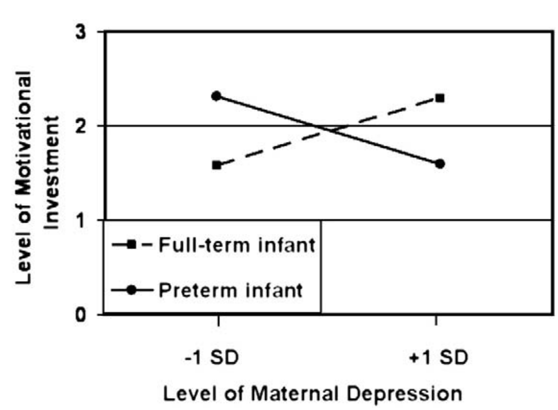

Fig. 2. Motivational evidence for contingent model of parental investment.

greater the depression, the lower the investment. The effects of maternal depression also reached significance (in the reverse direction) for full-term children (β=.44, p=.03).

Follow-up analyses failed to reveal any significant main or interactive effects for other types of resources (maternal education or presence of the father in the home).

3.2.2. Computational investment

The regression analysis testing the effects of maternal depression and child gestational age on motivational investment (i.e., perceptual distortion of children as "dependent," i.e., smaller than they are) revealed the predicted interaction (β=.30, p=.05). The specific pattern of interaction (shown in Fig. 3) is consistent with the contingency model but not the additive model of parental investment. Follow-up regression analyses were conducted separately for children that were full-term (greater than 36 weeks in gestational age) and for children that were preterm (less than 36 weeks in gestational age). Although the effects of maternal depression did not reach significance for preterm children (β=−.16), they approached significance (in the reverse direction) for full-term children (β=.38, p=.06) (Table 2).

Follow-up analysis failed to reveal any significant main or interactive effects for other types of resources (maternal education or presence of the father in the home).

3.3. Maternal age and parity

Regression analysis testing the interactive effects of maternal age and parity revealed a supportive trend for computational investment (β=.26, p=.08). A follow-up analysis conducted for the investment pattern found with singleton children was significant (β=.34, p=.05). That is, the older the mother, the greater her investment in singleton offspring. This effect was observed even if the sample was limited to primiparous mothers of *high-risk children* (β=.53, p=.05). However, no significant effects were found for motivational investment.

3.4. Child gender and maternal condition

Regression analyses were conducted to test effects predicted by the Trivers–Willard hypothesis (Trivers & Willard, 1973). In the first set of analyses, maternal depression was included as a marker of "maternal condition." No significant main or interaction effects were found for motivational investment. For computational investment, a significant interaction was found between maternal depression and child gender (β=.55, p=.05). However, follow-up analyses conducted separately for boys and girls failed to yield significant effects (or trends) for the extent to which maternal depression predicted investment.

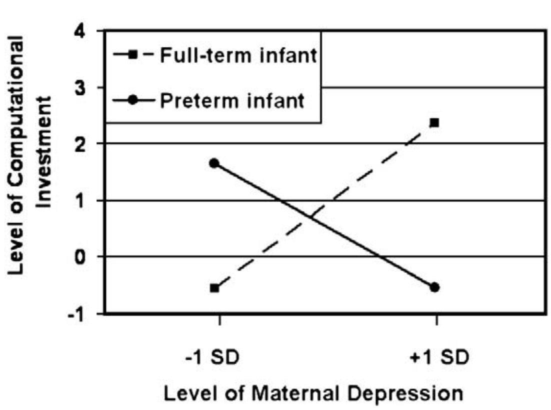

Fig. 3. Computational evidence for contingent model of parental investment.

Table 2
Computational bias consistent with parental investment

Step	Variable	B	S.E. (B)	β	R^2 change
Step 1					.01
	Participation in intervention	−0.55	1.02	−.08	
Step 2					.01
	Gestational age	0.02	0.14	.02	
	Level of depression (BDI)	0.04	0.06	.10	
Step 3					0.08 *
	Gestational Age × Depression	0.04	.02	.30 *	

* p<.05.

In the second set of analyses, maternal education was included as a marker of "maternal condition." No significant main or interaction effects were found.

3.5. Child birth order

The potential effects of birth order were tested in a multivariate analysis of variance that included both investment measures as dependent variables. Birth order (first-born vs. later- born status) was included as an independent variable. No significant effects or trends were found (F's <1).

4. Discussion

Support was found for a contingency model of parental investment with respect to the interactive effects of maternal resources and child reproductive potential. That is, there is a contingent relationship such that mothers who have low attentional resources (as reflected in their high levels of depression) are more likely to invest in a child who manifests cues to high reproductive potential than one who shows cues to low reproductive potential. Conversely, mothers who have high resources are more likely to invest in a child with cues to *low* reproductive potential than a child who show cues to high reproductive potential. The effects of low maternal resources (depression) and child reproductive potential (preterm status) were not found to be additive (in the sense of predictor variables combining to create additional risk).

These observations support both the predictions of Bugental and Beaulieu (2003) and Mann (1992) and are also consistent with past findings for nonhuman mothers.

The advantage of parental investment theory over traditional explanations in parenting research follows from its ability to explain automatic motivational and computational processes that occur without conscious appraisal. In this way, it is possible to explain equivalencies in parenting processes across humans and nonhumans.

4.1. Motivational indicators of parental investment

Motivational indicators of parental investment (zero-sum decisions with respect to benefits to the child vs. benefits to the self) provided clear support for predictions. That is, depressed mothers were more likely to allocate disproportional benefits to full-term infants than to pre-term infants. In contrast, non-depressed mothers were more likely to allocate benefits to preterm than full-term infants. This finding is analogous to the findings from nonhuman research in which mothers provide differential resources (food) to offspring on the basis of the characteristics of the young and the availability of resources. Although either model of investment predicts the findings obtained for depressed mothers, only the contingent model predicts the (somewhat counter-intuitive) pattern observed for nondepressed mothers.

4.2. Computational indicators of parental investment

As an indirect measure of parental investment, the predicted pattern was obtained for computational/perceptual processes that are relevant to caregiving responses. As noted earlier, mothers are less likely to engage in protective care if children appear older than they really are (McCabe, 1984). That is, protective care responses can be thought of activated in response to child cues shown at birth and deactivated when children are older. If mothers who have low resources (consistent with depressive symptoms) are confronted with a high-risk (premature) infant, they are less likely to activate the protective care system. Consistent with this expectation, depressed mothers were more likely to overestimate the height of their high-risk children, suggesting that they perceived them as older than they really were. In contrast, nondepressed mothers underestimated the height of their high-risk children, suggesting the activation of a protective care system. That is, their high-risk children are perceived as having characteristics consistent with the need for protective care.

4.3. Evidence for other hypotheses concerning parental investment

Predictions were also tested based on other possible bases of parental investment. For example, predictions were tested based on the Trivers–Willard hypothesis that differential investment occurs in male vs. female offspring based on the mother's condition. Employing maternal education and depressive symptoms as markers of maternal condition, no reliable support was found for predictions.

Predictions were also tested regarding the combined effects of maternal age and parity. It has been predicted that mothers are more likely to show increasing in parental investment in singleton children with increased age. That is, with the reduced possibility of later reproduction, they would maximize their reproductive successive by investing heavily in the one child they do have. Support was found for this prediction but only as measured by computational evidence for investment—in particular, for high-risk children. That is, older mothers of singleton high-risk children were likely to show perceptual distortions such that they were seen as very small, and thus in need of protective care. This finding is consistent with the automatic nature of the processes involved in parental investment and fully supports the findings of Hagen (2002). As a result of this observation, expectations regarding maternal investment regularly need to consider maternal age and the presence/number of other children.

Finally, no significant effects were found as a result of birth order. Children who were later born did not differ significantly from first-born children in the extent to which they were the recipients of parental investment.

4.4. Limitations

Although support was found for the contingent model of parental investment, replication is needed for the observed effects (with these or other similar types of measures). In addition, it will be useful to include other types of parental investment, for example, financial or time investment, as well as other examples of parental resources.

Other limitations (for testing our own as well as the predictions of others) reflect the nature of the sample. For example, the average education of mothers (9 years) was low and maternal depression was relatively high. Thus, the possibility of measuring the selective investment patterns of mothers with high resources (or in "good condition") was limited. In addition, the extent to which the presence of a father served as a resource may have been limited due to their typically low involvement in child care at early ages within this population. As another constraint, the age limitations in our sample (below 2 years of age) did not allow a reasonable test of the differential investment in middle-born vs. first-born or later-born children.

4.5. Conclusions

Parental investment theory, when approached from the perspective of an "if: then" decision-making model, provides a good explanation of the different ways that parents respond to their offspring as a function of their own resources and cues to the child's reproductive potential. Although either the additive or the conditional model predicts the low parental investment found in premature children by mothers who manifested postpartum depression, only the contingent model predicts the high investment in premature children among mothers who lack such symptoms. The combined pattern suggests that parental decisions are contingent on complex computations regarding the child's probable reproductive outcomes and their own ability (cognitively, emotionally, or attentionally) to provide care for that child. Commonalities found in the investment patterns shown by both nonhumans and humans (as evidenced here) suggest that there are shared evolutionary influences on these processes.

Acknowledgments

We would like to express our appreciation to the families who participated in this program of research and to the home visitors who provided services to families as well as assisted in the research process. This research was supported by a grant from the National Institutes of Health (RO1 MH19095).

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