

Differential susceptibility to long-term effects of quality of child care on externalizing behavior in adolescence?

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Abstract

Much research on the quality of child care reveals it—in the case of low-quality child care—to be related to poorer child functioning, net of confounding factors, perhaps especially in the case of cognitive-linguistic performance. Recent work using data from the National Institute of Child Health and Human Development (NICHD) Study of Early Child Care and Youth Development (USA) makes clear that when children's early negative emotionality/difficult temperament is taken into account, it also predicts externalizing problems reported by teachers through the primary school years. More negatively emotional infants are more affected—for better and for worse—by child care quality than less difficult ones, such that the latter appear unaffected by it but the former benefit from good quality care and are adversely affected by poor quality care. Here we determine whether the same is true when children are restudied in adolescence and the focus is their own reports of externalizing problems, impulsivity and risk taking. Results prove more consistent with a diathesis-stress model of environmental action than a differential-susceptibility-related one, in that 15-year-olds who were highly negative as infants report more externalizing behavior (but not risk taking or impulsivity) if they experienced low-quality child care, but not fewer problems if they experienced high-quality care relative to their counterparts with less difficult temperaments in infancy. Results are discussed in relation to physiological stress, with possible explanations offered as to why the predictive nature of child care experience might change over time.

Keywords

behavior problems, day care, stress reactivity, temperament

High-quality child care, at least at the process or proximate level of analysis, is typically conceived of as care in which caregivers prove to be attentive, responsive, stimulating and positive, and not intrusive, neglectful or negative. Widely appreciated is the fact that quality matters when it comes to understanding whether—and how—experience in child care in the opening years of life influences children's development. Whereas experimental studies of high-quality early intervention programs indicate that such efforts enhance cognitive and social development of economically disadvantaged children (e.g., Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; Love et al., 2005; Reynolds, 2000), correlational studies of more diverse samples also find higher quality child care to be associated principally with better cognitive, linguistic and academic outcomes (e.g., Burchinal, Peisner-Feinberg, Bryant, & Clifford, 2000; Côté et al., 2007; Mashburn et al., 2008).

NICHD Study of Early Child Care and Youth Development

Perhaps most noteworthy, though, given the focus of this report, is evidence pertaining to quality-of-care effects emanating from the large-scale American NICHD Study of Early Child Care and Youth Development (SECCYD) (NICHD Early Child Care Research Network [ECCRN], 2005a), as these emerged after taking into account family background factors and two other fundamental features of the child care experience, amount of care (i.e., hours/week) and type of care (i.e., center exposure). When it came to predicting infant–mother attachment security measured at age 15 months,

quality of care, like quantity and type of care, interacted with maternal sensitivity (NICHD Early Child Care Research Network [ECCRN], 1998). Thus, when maternal sensitivity was low, low quality of care increased the risk of infants developing insecure attachments (NICHD ECCRN, 2001a). When it came to predicting cognitive development (e.g., school readiness, language) at 24 and/or 36 months of age, lower quality care from infancy onward forecasted poorer functioning all by itself (i.e., main effect). Quality of care, though, failed to predict socioemotional functioning (NICHD ECCRN, 2006). This distinction and difference between cognitive-linguistic and socioemotional correlates of quality of care remained for the most part, with a few exceptions, until children reached adolescence (Belsky, Vandell, et al., 2007; NICHD ECCRN, 2005b, 2006; Vandell, Belsky, Burchinal, Steinberg, & Vandergrift, 2010), which is the focus of the present report.

Differential susceptibility to child care effects?

Although primary reports of the NICHD ECCRN examining effects of child care quality, quantity and type just before school entry and

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through the elementary school years failed to chronicle links between quality of care and problem behavior (Belsky, Vandell, et al., 2007; NICHD ECCRN, 2005b, 2006), such effects materialized when investigation moved beyond consideration of main effects. Pluess and Belsky (2009, 2010) found, consistent with expectations (Belsky, 2005), that at least some quality-of-care effects appear restricted to highly negative infants upon reanalyzing SECCYD data collected just before school entry and across the primary school years. In their first report, 54-month-olds with difficult temperaments as infants exhibited both more *caregiver-reported* behavior problems if they had experienced low-quality care and fewer if they had experienced high-quality care relative to children with easy temperaments; indeed, no quality-of-care effect emerged in the case of children without histories of difficult temperament in infancy. Similar results emerged in Pluess and Belsky's (2010) subsequent report when the outcomes to be explained were *teacher-reported* problem behavior and teacher-child conflict in sixth grade, around 11–12 years of age.

What was especially noteworthy about these temperament-moderated quality-of-care effects on socioemotional adjustment was that they reflected not a diathesis-stress pattern of environmental action (Monroe & Simons, 1991; Zuckerman, 1999), but an anticipated differential-susceptibility-related one (Belsky, 1997; Belsky & Pluess, 2009a, 2009b; Boyce & Ellis, 2005; Ellis, Boyce, Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2011). Thus, it was not just that children who were highly negatively emotional as infants were “at risk” of compromised development when experiencing contextual adversity (i.e., low-quality care); and this was because the same putatively “vulnerable” children benefited the most, in terms of manifesting fewer behavior problems, when they experienced high-quality care. Somewhat similar results emerged in work by Phillips et al. (Phillips, Crowell, et al., 2011; Phillips, Fox, & Gunnar, 2011), showing that higher quality caregiving was exclusively associated with less isolation from peers and adults at age 24 months in the case of children who were highly negatively reactive infants, with a developmental follow-up further revealing that more positive peer interactions in child care at 24 months predicted *less* wariness around unfamiliar peers a year later, but again only for children scoring high in temperamental fear (Almas, Phillips, & Fox, 2009). It should be noted, however, that Crockenberg and Leerkes (2005) failed to find evidence of infant negative emotionality moderating effects of quality of care when they sought to determine if this was the case.

Exactly why more negatively emotional/difficult infants should prove more susceptible to environmental influences is not entirely clear, but three different, yet not unrelated explanations have been advanced. Drawing on his primate evidence, Suomi (1995, 1997) suggested that highly fearful/inhibited/“up-tight” Rhesus-Macaques spent more time than other young monkeys observing the world around them, thereby learning more than others about how to function effectively in their social environment. Kochanska (1993) drew explicitly on Dienstbier's (1985) thinking on anxiety, arguing that more negatively emotional/fearful/inhibited infants have lower thresholds for anxiety, thereby making them more easily aroused by discipline and thus responsive to it. Finally, Belsky (2005) contended that a negatively emotional/difficult temperament reflects a highly sensitive nervous system on which experience—of both the positive and negative variety—registers especially strongly (see also Aron & Aron, 1997).

In any event, what the concept of differential susceptibility implies is that it may be mistaken to regard some children—like

highly negative infants—as simply more vulnerable to the negative effects of adversity. And this is because such children may also benefit more than others from environmental support and enrichment. Essentially, this is the difference between the traditional diathesis-stress model of environmental action and that of differential susceptibility (Belsky & Pluess, 2009a; Ellis et al., 2011). Whereas the former places emphasis on the disproportionate (or exclusive) susceptibility to negative contextual conditions in the case of some, the latter highlights the disproportionate susceptibility to both supportive *and* at-risk environments in the same individuals. To the extent that some children are more malleable or plastic than others in response to both positive and negative environmental conditions, this could have important implications for policy as it might not just inform prevention efforts but enhancement ones, too. Indeed, this could be one way of maximizing return on intervention investment—by targeting those most likely to benefit.

Current study

The purpose of the current study is to extend the prior Pluess and Belsky (2009, 2010) investigations to determine whether difficult temperament in infancy continues to moderate effects of child care quality on problem behavior in adolescence—at age 15 years. This is an interesting question for substantive and methodological reasons. Substantively, the issue is whether differential susceptibility to the positive *and* negative effects of, respectively, high- and low-quality care extend to the teenage years in the case of socioemotional functioning. Methodologically, the issue is whether the earlier detected differential-susceptibility effects prove discernible when measurement changes from caregiver and teacher reports obtained during early and middle childhood, respectively, to *adolescent self-reports*. That it might not is suggested by the fact that caregiver and teacher reports of externalizing problems during the early and middle-childhood years have proven only weakly related to adolescent self-reports in the NICHD SECCYD (Vandell et al., 2010). In view of the fact that assessments of socioemotional functioning at age 15 also included self-reports of risk-taking behavior and impulsivity, the current inquiry also evaluates whether quality-of-care effects on these outcomes are moderated by difficult temperament measured in infancy.

Method

Participants

The SECCYD recruited 1,364 families through hospital visits shortly after the birth of a child in 1991 at 10 U.S. locations (for sample and recruitment details, see NICHD ECCRN, 2001b). Due to attrition and missing data, only 842 of the original 1,364 cases contributed to this report. Children not included, relative to those included, came from households with lower income-to-needs ratios (2.82 vs. 3.58) and had less educated mothers (13.8 vs. 14.5 years), who were more likely to be single parents (20.1% vs. 14.4%) and who provided lower quality parenting (−.18 vs. .05). Excluded children were more likely to be boys (55.8% vs. 49.2%), spent significantly less time in child care (20.7 vs. 27.0 hours per week), and experienced a lower proportion of center care (0.17% vs. 0.22%) prior to starting school. Characteristics of the final sample and means of all variables are displayed in Table 1 (for the total sample and separately for individuals low or high in difficult temperament).

Table 1. Demographic characteristics of the total sample and low/high difficult-temperament subgroups (median split)

Variables	Total sample <i>N</i> = 842 <i>N</i> (%)	Low-difficulty subgroup <i>N</i> = 421 <i>N</i> (%)	High-difficulty subgroup <i>N</i> = 421 <i>N</i> (%)
Child gender			
Male	414 (49.2%)	207 (49.2%)	207 (49.2%)
Female	428 (50.8%)	214 (50.8%)	214 (50.8%)
Child ethnicity			
Caucasian	687 (81.6%)	355 (84.3%)	332 (78.9%)
Other	155 (18.4%)	66 (15.7%)	89 (21.1%)
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)
Child temperament	3.24 (.43)	2.90 (.27)	3.57 (.27)
Maternal education	14.51 (2.40)	14.67 (2.46)	14.35 (2.34)
Maternal depression	9.60 (6.26)	8.52 (6.04)	10.68 (6.30)
Parenting quality	.05 (.68)	.12 (.63)	-.01 (.72)
Partner presence	85.65 (29.45)	85.94 (29.38)	85.36 (29.59)
Income	3.58 (2.73)	3.80 (2.94)	3.37 (2.48)
Center child care	.22 (.26)	.23 (.27)	.22 (.25)
Child care quality	2.82 (.24)	2.82 (.24)	2.80 (.24)
Child care quantity	27.03 (15.25)	27.29 (15.56)	26.77 (14.94)
Externalizing problems	49.17 (9.90)	48.34 (9.42)	50.00 (10.29)
Impulsivity	3.52 (.89)	3.61 (.83)	3.42 (.94)
Risk taking ¹	6.03 (5.63)	5.80 (5.62)	6.26 (5.64)

Note. ¹Sample sizes for risk taking were: *N* = 839 for the total sample, *N* = 418 for the low-difficulty subgroup and *N* = 421 for the high-difficulty subgroup.

Procedures and measures

Information about children and parents came from interviews with mothers when children were 1, 6, 15, 24, 36 and 54 months old and in the fall of the kindergarten year. Observations of mother–child interaction were made at the same points (except Month 1). Information about child care and family context was obtained from telephone interviews when children were 3, 9, 12, 18, 21, 27, 30, 33, 42, 46, 50 and 60 months old. Developmental outcomes for purposes of this inquiry were obtained when children were 15 years of age. For details about all data-collection procedures see <http://www.nichd.nih.gov/research/supported/seccyd.cfm>.

Primary predictor variables

Temperament. Infant temperament was assessed by maternal report at 1 and 6 months using an adapted version of the Infant Temperament Questionnaire (Carey & McDevitt, 1978). Mothers indicated on a 6-point rating scale, ranging from “almost never” to “almost always,” how often their baby’s behavior corresponded to the behavior described in each item. The 55 selected items provided scores for five of the original nine subscales: (a) activity (e.g., “My baby plays actively with parents—much movement of arms, legs, body”), (b) approach (e.g., “My baby’s initial reaction to a new babysitter is rejection [crying, clinging to mother, etc.]”), (c) adaptability (e.g., “My baby is still wary or frightened of strangers after 15 minutes”), (d) mood (e.g., “My baby cries when left to play alone”) and (e) intensity (e.g., “My baby reacts strongly to strangers: laughing or crying”). At each age an overall summary of “difficulty” was calculated ($\alpha = .67$ at 1 month and $\alpha = .81$ at 6 months). The two assessment were significantly correlated with $r = .31, p < .01$. In order to create a more reliable measure of infant temperament both measures were averaged, with higher values reflecting more difficult temperament.

Child care quality. Observational assessments were conducted in the primary child care arrangement at ages 6, 15, 24, 36 and 54 months. Quality was assessed during 2 half-day visits scheduled within a 2-week interval at 6–36 months and 1 half-day visit at 54 months. Observers completed four 44-min cycles of the Observational Record of the Caregiving Environment (ORCE) per child age through 36 months and two 44-min ORCE cycles at 54 months. Detailed descriptions of the ORCE assessments can be found in NICHD ECCRN (2002), including coding definitions, training procedures and interobserver agreement. Observations of caregiver sensitivity were summarized using the hierarchical linear modeling (HLM). Higher quality scores reflect children’s experience with caregivers who were more attentive, stimulating, positively affectionate and less intrusive and negative.

Developmental outcome variables

Externalizing problems. Adolescents self-reported externalizing behaviors using the Youth Self-Report (YSR; Achenbach & Rescorla, 2001). The scale consists of 119 items that reflect a broad range of behavioral/emotional problems as well as 16 socially desirable items. For each item, the adolescent is asked to rate how well that item describes him or her currently or within the last 6 months on a 3-point scale (0 = *not true*, 1 = *somewhat or sometimes true*, 2 = *very true or often true*). The format of the YSR is similar to that of the Child Behavior Checklist completed by parents (CBCL; Achenbach, 1991a) and the Teacher Report Form completed by teachers (TRF; Achenbach, 1991b). The YSR, CBCL and TRF have 89 problem items in common, but the YSR includes additional items that are specifically designed for adolescents. Externalizing behaviors are assessed by 30 items ($\alpha = .86$). Higher values reflect more externalizing problems. None of the adolescents reported externalizing problems above the clinical cut-off (90th percentile).

Table 2. Unadjusted associations between variables ($N = 842$)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Child gender (1 = Male; 2 = Female)	—												
2 Child ethnicity (1 = Caucasian; 0 = Other)	.02	—											
3 Child temperament	-.03	-.10**	—										
4 Maternal education	.02	.22**	-.01	—									
5 Maternal depression	.01	-.2**	.20**	-.33**	—								
6 Parenting quality	.07	.48**	-.10**	.56**	-.41**	—							
7 Partner presence	.05	.41**	-.05	.30**	-.28**	.46**	—						
8 Income	.03	.26**	-.04	.55**	-.32**	.49**	.37**	—					
9 Center child care	<.01	<.01	<.01	.11**	.02	.06	-.03	.13**	—				
10 Child care quality	.07*	.17**	.01	.21**	-.09**	.32**	.20**	.25**	-.19**	—			
11 Child care quantity	-.01	-.02	-.03	.07*	-.04	-.04	-.09**	.09**	.37**	-.11**	—		
12 Externalizing problems	.08*	-.12**	.09*	-.10**	.11**	-.10**	-.19**	-.15**	.02	-.07*	.05	—	
13 Impulsivity	.07*	.09**	-.09*	.14**	-.09**	.16**	.12**	.16**	-.03	.10**	-.11**	-.61**	—
14 Risk taking ¹	-.17**	-.24**	.05	-.17**	.14**	-.23**	-.27**	-.22**	.02	-.13**	.08*	.54**	-.45**

Note. ¹Sample size for risk taking was $N = 839$; * $p < .05$; ** $p < .01$.

Risk taking. Adolescents reported risk-taking behaviors using an audio computer-assisted self-interview. Thirty-six risk-taking items were drawn from instruments used in prior studies of adolescents (Halpern-Felsher, Biehl, Kropp, & Rubinstein, 2004). Adolescents reported the extent to which, over the past year, they used alcohol, tobacco or other drugs, behaved in ways that threatened their own safety (e.g., rode in a vehicle without the use of seatbelts), used or threatened to use a weapon, stole something or harmed property. Responses were made on a 3-point scale (0 = *never*, 1 = *once or twice*, 2 = *more than twice*). Ratings were summed across component items and then subjected to square-root transformation to reduce skew and kurtosis with higher values indicating more risk taking ($\alpha = .89$).

Impulsivity. Adolescents completed an eight-item questionnaire to assess reactions to external constraints, taken from the Weinberger Adjustment Inventory (Weinberger & Schwartz, 1990). The measure asks participants to rate (1 = *false* to 5 = *true*) how closely their behavior matched a series of statements. Sample items include: "I'm the kind of person who will try anything once, even if it's not that safe," "I should try harder to control myself when I'm having fun," "I do things without giving them enough thought." Seven items were used to create an impulsivity composite score, with lower scores indicating less impulse control/higher impulsivity ($\alpha = .82$).

Early childhood covariates

Family background factors. A mean family *income-to-needs* (ITN) ratio was calculated from data gathered at 1, 6, 15, 24, 36 and 54 months, and kindergarten age, by dividing total family income by the poverty threshold for family size (see NICHD ECCRN, 2001b). Mother's years of *education* was obtained at the 1-month enrollment interview. The *presence of a husband/partner* in the home was operationalized as proportion of 3–4 month epochs (birth through kindergarten) in which mother reported a *husband/partner* present. *Child gender* was coded 1 = *male* and 2 = *female*, and child ethnicity 0 = *other* and 1 = *Caucasian*. Self-reported

maternal depressive symptoms were assessed at 1, 6, 15, 24, 36 and 54 months, using the Center for Epidemiological Studies Depression Scale (Radloff, 1977); scores were averaged over time.

Parenting quality. A composite measure of parenting was based on ratings of maternal sensitivity during 15-minute videotaped interactions at 6, 15, 24, 36 and 54 months, and scores of the Home Observation for Measurement of the Environment (HOME; Caldwell & Bradley, 1984) at the same ages except 24 months. The HOME and maternal-sensitivity ratings were standardized and averaged within and then across age to create a *parenting quality* composite score.

Type of care. For each of the 16 3–4 month intervals, each of the child's care arrangements was classified as center, child care home (any home-based care outside the child's own home except care by grandparents), in-home care (any caregiver in the child's own home except father or grandparent), grandparent care or father care. The proportion of 17 measurement epochs in which the child received care in a center for at least 10 hours per week was used as variable to represent type of care.

Child care quantity. Parents provided information on hours of routine nonmaternal care during phone and personal interviews, and HLM analyses were used to summarize these data (see NICHD ECCRN, 2003, 2005a), yielding continuous summary scores describing quantity of nonfamilial care over the first 4.5 years of life. The intercept of hours per week (at 27 months) that children experienced child care during the 16 intervals from 1–54 months was used for this study.

Results

Two sets of results are presented, the first preliminary, addressing simple bivariate relations among variables, and the second primary, addressing prediction of adolescent's externalizing behaviors, impulsivity and risk taking.

Table 3. Summary of hierarchical regression analyses

Predictor variables		Externalizing problems β	Impulsivity β	Risk taking β
Step 1				
	Child gender (1 = Male; 2 = Female)	.08*	.06#	-.15**
	Child ethnicity (0 = Other; 1 = Caucasian)	-.05	.01	-.13**
	Child temperament	-.01	.01	-.03
	Maternal education	-.03	.05	-.03
	Maternal depression	.04	-.01	.04
	Parenting quality	.08#	.03	.01
	Partner presence	-.15**	.03	-.14**
	Income	-.08#	.10*	-.10*
	Center child care	<.01	<.01	<.01
	Child care quality	-.03	.03	-.03
	Child care quantity	.05	-.11**	.07#
	R²:	.058	.051	.133
	F:	4.64**	4.02**	11.51**
Step 2				
	Temperament x Child care quality	-.07*	.04	<.01
	R²:	.063	.052	.133
	F:	4.64**	3.80**	10.54**
	R² Change:	.005	.002	<.001
	F Change:	4.43*	1.34	.02

Note. The displayed coefficients of the variables at Step 1 represent the values after inclusion of interaction terms at Step 2; $N = 842$ except for risk taking with $N = 839$. # $p < .10$; * $p < .05$; ** $p < .01$.

Preliminary analysis: Unadjusted associations

Table 2 presents bivariate correlations between study variables. Most notably, although child temperament was not significantly associated with child care quality, it was significantly correlated with externalizing behavior problems ($r = .09$, $p < .05$) and with impulsivity ($r = -.09$, $p < .05$). As the independence of the moderator variable (i.e., infant negativity) from outcome (i.e., externalizing problems) is a necessary prerequisite for testing differential susceptibility (Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2007), externalizing problems and impulsivity were residualized for child temperament. This was not necessary for risk taking as there was no significant correlation between temperament and risk taking.

Primary analyses: Temperament \times Child care interactions

For the primary analyses, we ran three separate hierarchical regression models, one for each of the three outcome measures. Predictor variables were entered in two steps, with the first including all the covariates and the main effects of child care quality and temperament and the second adding the two-way interaction between child care quality and infant temperament. Model 1 results pertaining to main-effect findings indicated that externalizing problems were greater when children were female (net of all controls) and when they lived in a single-parent home (i.e., less partner presence). Greater risk taking was significantly associated with male gender, non-Caucasian ethnicity, lower family income and higher proportion of partner absence. Finally, greater impulsivity was predicted by lower family income and greater exposure to any nonmaternal child care in the early childhood years. Model 2 results indicated that child care quality significantly interacted with infant temperament in predicting adolescent-reported externalizing behavior

problems ($\beta = -.07$, $p = .04$, $f^2 = .005$), but not risk taking or impulsivity (see Table 3). In order to illuminate the nature of the significant interaction, we plotted regression slopes of child care quality on externalizing problems separately for adolescents low and high in infant negative emotionality/difficulty, defined by median split. Figure 1 indicates that whereas the relation between child care quality and externalizing problems was negative and significant in the case of children who as infants scored high on negative emotionality/difficulty ($\beta = -.13$, $p < .01$), it was not significant and close to zero in the case of children who, as infants, scored low on infant difficulty ($\beta = -.02$, $p = .73$). After z -transformation of the standardized regression coefficients (Fisher, 1924), the difference between slopes of children low and high in difficulty proved marginally significant ($p = .06$).

Although visual inspection of Figure 1 reveals a cross-over interaction consistent with differential susceptibility, in that adolescents with difficult infant temperament had the highest externalizing problems scores when exposed to low-quality child care early in life and the lowest externalizing problems scores when child care quality was high, the former difference appears substantially greater than the latter. In order to test whether the significant interaction was more consistent with a diathesis-stress or differential-susceptibility pattern, we conducted a "regions of significance" analysis (Aiken & West, 1991; Hayes & Matthes, 2009; Preacher, Curran, & Bauer, 2006), a technique recently used by Kochanska, Kim, Barry, and Philibert (in press) to distinguish empirically differential susceptibility from diathesis stress. The region of significance defines the specific value of child care quality at which the slope between temperament and externalizing problems moves from significance to nonsignificance (and/or vice versa). A differential-susceptibility pattern would yield both upper and lower bounds of the region of significance within the observed child care quality range. Analysis of the data on which Figure 1 was based, using a tool provided by Hayes and Matthes (2009), yielded only a lower bound of significance within the observed range of

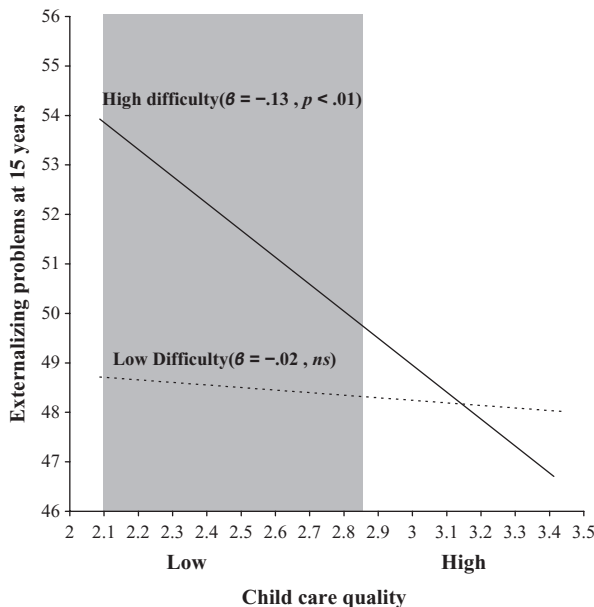


Figure 1. Child care quality by child temperament interaction predicting adolescent reported externalizing problems at 15 years. The shaded area represents the region of significance (child care quality < 2.84).

child care quality; more specifically, the slope between temperament and externalizing problems proved significant only when child care quality was less than 2.84 and there were no significant differences above this value (see shaded area in Figure 1). Consequently, the significant interaction between child care quality and temperament in predicting externalizing problems was more consistent with diathesis-stress than differential-susceptibility models of environmental action.

Discussion

When it comes to understanding any effects of child care, including of child care quality on children's development, multiple explanations have been advanced. One supposition is that a lack of cognitive and especially language stimulation associated with poor quality care early in life undermines foundational cognitive-linguistic skills and, thereby, later academic achievement. But the stressful nature of long hours in care and of exposure to low-quality care have also been highlighted. Perhaps the most compelling evidence that stress may be an important mediator of adverse child care effects comes from research on the stress-response system (Crockenberg, 2003). In one early study of preschoolers in full-day, center-based care, Tout, de Haan, Campbell, and Gunnar (1998) found that cortisol levels for 81% of children rose from morning to afternoon, a reverse of the expected circadian decrease across the day (Knutsson et al., 1997; Shimada, Takahashi, Ohkawa, Segawa, & Higurashi, 1995). Dettling, Gunnar, and Donzella (1999) subsequently reported that this increase was particularly pronounced for 3- and 4-year-olds, not those 5 or 7 years of age; and Watamura, Donzella, Alwin, and Gunnar (2003) detected it among infants and toddlers, too. Vermeer and van Ijzendoorn (2006) recently conducted a meta-analysis of nine studies, finding that day-care children displayed higher cortisol levels compared to home settings, with day care, especially for children younger than 36 months, being associated with significant increases from

morning to afternoon (see also Geoffroy, Côté, Parent, & Séguin, 2006).

Dettling, Parker, Lane, Sebanc, and Gunnar (2000) were the first stress-reactivity researchers to raise the issue of whether the quality of child care mattered in their research on home-based child care. They found that children in settings that were low in quality (i.e., low attention, stimulation) exhibited a reversal of the typical pattern of cortisol production from morning to afternoon, whereas those in settings higher in quality exhibited no change in cortisol from home to child care (see also Sims, Guilfoyle, & Parry, 2006). Consistent with these results are Gunnar, Kryzer, van Ryzin, and Phillips' (2010) new findings showing that more intrusive and overcontrolling care—but not how warm and supportive the care—predicted greater increases in cortisol during the day in family day care. Considered together, these data clearly suggest that low-quality care is physiologically stressful to young children and could, perhaps, account for some of the adverse effects of low-quality care reported in the literature. The fact that Dettling et al. (2000) and Watamura et al. (2003) also observed that elevated cortisol across the day proved most pronounced among children manifesting high levels of negative emotionality or fearfulness, raised the possibility that children vary in their susceptibility to adverse effects of low-quality care (Gunnar et al., 2010).

This summary of cortisol-related child care findings highlighting the importance of both low-quality care and infant temperament might well account for the primary results to emerge from this inquiry. Recall that when it came to predicting socioemotional functioning in adolescence using observational data on child care quality obtained across the first 4.5 years of life, linkages were discerned; but this proved true only in the case of teenagers who had been highly negative/difficult as young infants (according to maternal report). Just as significant, although the anticipated Quality of care \times Temperament interaction emerged (only) in the case of externalizing problems, seeming to mirror prior differential-susceptibility-related results discerned in early childhood (Pluess & Belsky, 2009) and across the primary school years (Pluess & Belsky, 2010) when relying, respectively, on caregiver and teacher reports, findings presented here based on adolescent self-reports proved somewhat different. Recall that the regions of significance analysis indicated that adolescents who had been high and low in negative emotionality as infants differed from one another on externalizing behavior to a significant extent only under conditions of low-quality child care, not high-quality care. Of note is that some 60.5% of the child care experienced by the children in this study was in the region of quality in which the significant difference emerged.

The pattern of results discerned is more consistent with a diathesis-stress model of environmental action than a differential-susceptibility one. This is because infant negativity operated principally, if not exclusively in this inquiry as a "vulnerability" factor, not also an enhancement one. For the differential-susceptibility model to have received strong empirical support, some range of good-quality care would also have had to fall within the region of significance in that analysis—which it did not. Thus, even though visual inspection of Figure 1 suggested a differential-susceptibility pattern of environmental action, with those adolescents who were highly negative as infants scoring both better and worse than their low-negativity counterparts when, respectively, having been exposed to high- and low-quality child care, rigorous analysis only supported the "for worse" side of the differential-susceptibility equation, thus reflecting diathesis-stress alone.

There are two obvious reasons why differential susceptibility might not have emerged in this Study of adolescent functioning, in contrast to findings reported in the NICHD Study sample when children were 54 months of age (Pluess & Belsky, 2009)—and when the same regions of significance analysis performed here was applied to these earlier data (results available on request). On the one hand, the change in measurement might have had something to do with it, given the low cross-time stability coefficients discerned by Vandell et al. (2010) between earlier adult reports of children's externalizing problems and adolescent self-reports. But just as plausible is that the enhancement effect of good-quality care on highly difficult infants might simply wane over time whereas the undermining effect of poor-quality care does not. Perhaps benefits of good-quality care erode more easily, especially if not sustained by supportive schooling experiences, whereas adverse effects of poor-quality care get sustained through transactional processes; that is, children engaging in somewhat more aggression and disobedience than other children provoke responses from peers and adults which maintain such behavior into the second decade of life.

It is also unclear why the anticipated Quality of care \times Temperament interaction did not emerge in the case of impulsivity and risk taking, two adolescent outcomes found by Vandell et al. (2010) to be (negatively) predicted by cumulative child care exposure (irrespective of quality) across the infant, toddler and preschool years, but not by quality of care. In that work, quality actually exerted a (negative) main effect on externalizing problems, a result inconsistent with the null effects of quality on externalizing problems that had been found at all assessment periods after age 3 years. This change over age in predictive influence of child care quality also raised the issue of whether something developmental was responsible (like a sleeper effect) or whether it was the change in measurement—from adult to adolescent reporters of externalizing problems—that accounted for the change in the predictive power of child care quality over time. It should be noted that the reason the current inquiry did not detect a main effect of child care quality on externalizing problems was because, unlike in Vandell et al.'s (2010) inquiry, missing data on the adolescent outcomes was not inferred using structural equation modeling as it was in the just-cited work. That is, we only relied on cases for which adolescent self-reports were actually available.

Whether children with certain temperaments are more vulnerable, as a diathesis-stress perspective presumes, or more malleable, as a differential-susceptibility framework presumes, may ultimately depend upon the features of experience and the aspects of development under consideration. Thus, the findings reported here pertaining to child care quality and externalizing problems should not be glibly generalized to other environmental conditions and/or developmental outcomes. This observation highlights a critical limitation of the present report, namely, its narrow focus on quality of child care and a few measures of socioemotional adjustment in adolescence. Also needing to be highlighted in this brief consideration of study limitations is the correlational nature of this inquiry which precludes any strong causal inferences from being made.

Beyond highlighting such limitations, directions for future research are worth considering. Perhaps most importantly, future work should determine whether, in fact, highly negative infants who seem to be especially vulnerable to the adverse effects of poor-quality care on externalizing problems, as well as the beneficial effects of good-quality care at ages prior to adolescence, are more physiologically stressed while in child care and whether it is this effect which accounts for the findings reported here and in

Pluess and Belsky (2009, 2010). Given the summary of child care studies involving cortisol measurement which open this discussion, along with Boyce and Ellis' (2005) proposal that highly physiologically reactive children are especially susceptible to environmental influences, there would seem to be reason to predict that controlling for physiological stress would mitigate the moderating effect of infant negative emotionality on externalizing problems. Only research that measured child care quality, negative emotionality, physiological reactivity and, eventually, externalizing problems would be positioned to test this possibility.

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