

Differential susceptibility to rearing experience: the case of childcare

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Background: Inconsistencies regarding developmental effects of non-maternal childcare may be caused by neglecting the possibility that children are differentially susceptible towards such experiences. **Method:** Interactions between difficult/negative child temperament and childcare type, quantity, and quality on teacher-rated behavior problems and social competence at 54 months and in kindergarten were investigated via multiple regression using data from the NICHD Study of Early Child Care. **Results:** Childcare quality interacted with infant negativity in predicting behavior problems and social competence, whereas effects of quantity and type were independent of child temperament. Consistent with Belsky's (1997) differential susceptibility hypothesis, children with difficult temperaments as infants exhibited both more behavior problems when faced with low quality care and fewer when experiencing high quality care than children with easy temperaments. **Conclusions:** Negatively-emotional infants appear to be more affected by the quality of care they experience – both negatively and positively – than other young children. **Keywords:** Development, day care, temperament, behavior problems, preschool children, prosocial behavior.

Developmental effects of childcare have been investigated extensively (Lamb & Ahnert, 2006), leading to some widely-embraced conclusions and other contested ones (Belsky, 2001). The current investigation addresses the latter, testing the proposition that some of the inconsistency in the literature derives from the relative absence of efforts to address the hypothesis that, like many experiential influences, childcare does not affect all children in the same way. Were this shown to be so, it would be consistent with recent gene \times environment ($G \times E$) interaction evidence indicating that even experiences as putatively damaging as child maltreatment do not promote psychopathology to the same extent in all individuals (Caspi et al., 2002; Caspi et al., 2003); indeed, with respect to anti-social behavior and depression, some prove entirely unaffected.

Thus, we address the question whether some children are more affected by childcare, particularly the quantity, quality and type of care they experience, than are others. Although we do not measure genes or focus upon psychopathology, the research does address the potential moderating effect of one feature of early temperament, negative emotionality, that has been linked to psychopathology (Caspi, Moffitt, Newman, & Silva, 1996) and to the serotonin transporter polymorphism (Auerbach et al., 1999) which has itself figured prominently in recent $G \times E$ research (e.g., Caspi et al., 2003; Taylor et al., 2006). For reasons outlined below, we predict that more negatively-emotional infants, that is, ones who score high on a measure of 'difficult temperament', will be more affected – in both positive and negative

ways – by childcare than are others. Such a finding would be consistent with the just-cited molecular-genetic and $G \times E$ research, as it is individuals with short serotonin transporter alleles who are more negatively emotional as infants and appear more affected by childrearing experience and life events.

Childcare and child development

Perhaps the most widely replicated finding in childcare research is that more attentive, responsive and stimulating care – that is, higher-quality care – predicts (somewhat) enhanced cognitive-linguistic-academic functioning (e.g., Bradley & Vandell, 2007; Peisner-Feinberg et al., 2001; NICHD Early Child Care Research Network [ECCRN], 2002). In contrast, findings regarding the effects of childcare quality on socioemotional development remain open to dispute (e.g., Love et al., 2003). Whereas some research shows higher childcare quality to be related to less problematic behavior or greater social competence (e.g., Burchinal, Peisner-Feinberg, Bryant, & Clifford, 2000; Crockenberg & Leerkes, 2005; Loeb, Fuller, Kagan, & Carrol, 2004), other studies fail to chronicle such effects (e.g., NICHD ECCRN, 2002, 2005b; Deater-Deckard, Pinkerton, & Scarr, 1996).

Even more contested than the possibility that childcare quality does not influence children's social functioning is the proposition that lots of time spent in any kind of childcare and/or in center-based group care in particular is predictive of (somewhat) elevated levels of externalizing behavior problems (Belsky, 2001). Indeed, heated debate surrounding this very notion (Belsky, 1986; Phillips, McCartney, & Scarr, 1987a; Clarke-Stewart, 1988), along with the dramatic growth in America in the 1980s in the

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utilization of non-maternal childcare during the opening years of life, served as impetus for launching the large-scale, NICHD Study of Early Child Care and Youth Development (NICHD SECC), data from which is used in this report (NICHD ECCRN, 2005a). Although the NICHD SECC has repeatedly reported findings consistent with this controversial claim (NICHD ECCRN, 2005b, 2002, 2003), as have others (e.g., Côté, Borge, Geoffroy, Rutter, & Tremblay, 2008; Loeb, Bridges, Bassok, Fuller, & Rumberger, 2007), it remains true that not all investigations chronicle linkages between high dosage of early care and higher levels of aggression and disobedience (e.g., Côté et al., 2007).

Even though some investigations reveal associations of high dosages of childcare with elevated levels of externalizing problem behavior, there is no evidence that childcare predicts diagnosable psychopathology. Caregiver- and teacher-report data, obtained just before school entry and soon thereafter, does show, however, that early, extensive and continuous childcare is predictive of behavior-problem scores in the at-risk, even if not clinical range in the NICHD SECC (NICHD ECCRN, 2003). But even if this were not the case, one should not lose sight of the fact that even modest increases in aggression and disobedience, when they apply to many children, could be of social consequence. Indeed, recent research by Dmitrieva, Steinberg, and Belsky (2007) indicates that the more children in a kindergarten classroom with extensive child care experience, the more all children manifest aggressive and disobedient behavior, irrespective of personal childcare histories. In other words, small effects on many can accumulate within social systems, be they classrooms, schools or communities.

Perhaps even more surprising than evidence linking dosage of any kind of non-maternal care and/or exposure to center-based care in particular with increased problem behavior has been the general failure of quality of care to account for this result when it does emerge, as long hypothesized (Phillips, McCartney, & Scarr, 1987b; McGurk, Caplan, Hennessy, & Moss, 1993). Most notably, the adverse effect of early, extensive and continuous childcare on problem behavior detected repeatedly in the NICHD SECC (NICHD ECCRN, 2002, 2003, 2005b) obtains – virtually unchanged – even after quality of care is statistically controlled, meaning that these effects apply to children experiencing low, moderate, and even high quality care. What makes these results so surprising is that the NICHD ECCRN (2005b) expended considerable effort developing an age-sensitive, observational system for assessing childcare quality that it used when children were 6, 15, 24, 36 and 54 months of age in order to test the proposition that it is quality of care rather than type or dosage of care that shapes children's development.

Differential susceptibility

In view of empirical findings – or lack thereof – pertaining to childcare effects on young children's social functioning, the research reported herein addresses the possibility that the NICHD SECC may have underestimated effects on social outcomes of quality of care in particular (but also effects of quantity and type of care) by not considering the differential-susceptibility hypothesis (Belsky, 1997; Belsky, Bakermans-Kranenburg, & van Ijzendoorn, 2007), that is, that children vary in whether they are affected by their rearing experiences. Thus, the core proposition guiding this inquiry is not simply that some children's social functioning will be more influenced by childcare than others, but that susceptibility will be moderated by infant negative emotionality/temperamental difficulty. (Throughout this paper, negative emotionality and difficult temperament are used interchangeably because negative emotionality is the defining and central feature of measured difficult temperament.)

Not only is there repeated indication that more negatively-emotional infants are more affected – for better and for worse (i.e., both positively and negatively) – by the parenting they experience than other children (for review, see Belsky, 2005), but some recent evidence suggests that the same may be true in the case of childcare. After detecting a childcare \times temperament interaction in predicting externalizing problems, Crockenberg and Leerkes (2005) found that easily-frustrated infants displayed more externalizing behavior at the age of 30 months when exposed to center care compared to other types of care, but that no such effect obtained for children manifesting less distress in the face of frustration. Relatedly, earlier work by Volling and Feagans (1995) revealed that infants rated high in social fear benefited more from high quality care as reflected in more positive peer interactions at age 30 months than those rated low in social fear. Also noteworthy is evidence that infant negative emotionality moderates the effect of childcare quality on diurnal cortisol patterns (Dettling, Parker, Lane, Sebanc, & Gunnar, 2000): Low quality childcare predicted an increase of salivary cortisol from morning to afternoon (in contrast to the expected decrease), but only in the case of children who were highly negative on a temperamental assessment.

Clearly, these results suggest that more negatively-emotional infants and toddlers may be more susceptible not just to effects of parenting, but to childcare as well. As such evidence of differential susceptibility to parenting has recently been documented using the NICHD-SECC data (Bradley & Corwyn, 2008; Dopkins Stright, Cranley Gallagher, & Kelley, 2008), in the present inquiry we test whether more negatively-emotional infants will prove more susceptible to childcare, too, especially childcare quality which has generally failed to predict

social functioning in this large-scale investigation. Moreover, consistent with the tenets of the differential-susceptibility hypothesis (Belsky et al., 2007), we evaluate not simply whether childcare predicts problematic outcomes more powerfully for highly negative infants, but positive outcomes, too; thus we focus upon externalizing problems and social competence reported by childcare providers when children are 4.5 years old and teachers in the first year of school (i.e., kindergarten). We also check whether infant negativity predicts childcare experience given such evidence in one small study (Sussman, Crowell, Phillips, Hane, & Fox, in press), as such moderator–predictor correlations would weaken the case for differential susceptibility by raising the prospect that negatively-emotional infants evoke certain childcare experiences which then affect them.

Method

Participants

The NICHD SECC recruited 1364 families through hospital visits shortly after the birth of a child in 1991 at 10 US locations (for detailed description of recruitment procedures and sample characteristics see NICHD ECCRN, 2001). Due to attrition and missing data, only 968 of the originally 1364 cases contribute to this report, with sample sizes for any analysis ranging from 761 to 915 children. The 396 incomplete cases differed on a number of demographic and psychosocial measures from the 968 complete cases. At study enrollment, mothers of the incomplete sample were significantly younger (26.9 vs. 28.6 years), more depressed (10.70 vs. 9.55), less educated (13.6 vs. 14.5 years), had a lower income-to-needs ratio (2.52 vs. 3.60), and were more likely to be divorced/separated or living without a partner (22.5% vs. 11%) than mothers of the complete sample. Children of the incomplete sample were more likely to be of minority status (26.0% vs. 16.8%), spent significantly less time in childcare (19.1 vs. 26.7 hours/week), and experienced a lower proportion of center care (.12% vs. .23%) across their opening years of life.

Procedures and measures

Information about children/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 one month). Information about childcare 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. Details about data collection procedures and reliability of measures are documented in Manuals of Operation of the study, located at <http://public.rti.org/secc/>.

Temperament. Temperament was assessed by maternal report at 1 and 6 months using adapted versions of the Infant Temperament Questionnaire (Carey & McDevitt, 1978). Items were designed to capture

approach, activity, intensity, mood, and adaptability. At each age point an overall summary of ‘difficultness’ was calculated, with higher values reflecting higher negative emotionality. For the purpose of this study, temperament scores at 1 and 6 months were averaged to construct a more reliable measure.

Type of care. For each 3–4-month interval (16 epochs in all), the child’s primary care arrangement was classified as center, childcare home (home-based care outside child’s own home except care by grandparents), in-home care (caregiver in child’s home except father/grandparent), grandparent care, or father care. Following practice of the NICHD Early Child Care Research Network (2003, 2005a), the proportion of epochs the child received care in a center was used to represent type of care.

Childcare quantity. Parents were asked about the hours of routine non-maternal care during phone and personal interviews. Hours spent in all settings were summarized using hierarchical linear model (HLM) analyses (see NICHD ECCRN 2005a; 2003), yielding parsimonious, interpretable, and continuous summary scores describing quantity of childcare over the first 4.5 years of life by estimating individual measures reflecting overall amount of care. Unconditional quartic individual growth curves were estimated, with age centered at 27 months. The intercept of hours/week that children experienced childcare during the 16 intervals from 1–54 months was used for this study.

Childcare quality. Quality was defined in terms of caregiver–child interaction. Observational assessments were conducted in the primary childcare arrangement at ages 6, 15, 24, 36, and 54 months. Quality was assessed during two half-day visits scheduled within a 2-week interval at 6–36 months and one half-day visit at 54 months. Observers completed four 44-minute 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. Observations of caregiver sensitivity were summarized using HLM. Unconditional linear growth curves were fit and individual intercepts were estimated. Detailed descriptions of the ORCE assessments and of the HLM analysis appear in NICHD Early Child Care Research Network. (2002, 2005a).

Behavior problems. Behavior problems were reported by caregivers at age 54 months and by kindergarten teachers using the Child Behavior Checklist (Achenbach, 1991). The caregiver/teacher version developed for 2–5-year-olds consists of 100 items and two subscales: Internalizing Problems and Externalizing Problems. Raw total problem scores were converted into standard T-scores, based on normative data.

Social competence. Social competence at 54 months was measured by caregivers completing the *California Preschool Social Competency Scale* (Levine, Elzey, & Lewis, 1969), a 30-item instrument assessing a range of social competencies especially relevant in childcare

settings (e.g., safe use of equipment, using names of others, greeting new child, initiating group activities). Raw scores were converted into standard T-scores, based on normative data for young children. The Total Social Competency score was the sum of the 30 items. Kindergarten teachers rated social competence using the Social Skills Questionnaire from the *Social Skills Rating System* (Gresham & Elliott, 1990) which is composed of 38 items concerning cooperation, assertion, responsibility, and self-control. Items were rated on a 3-point scale and summed for purposes of this study.

Maternal/child/family covariates. The following variables were included in analyses to control for their well-established associations with the child outcome measures. A family *income-to-needs* (ITN) ratio was calculated from data gathered at 1, 6, 15, 24, 36, 54 months, and kindergarten. ITN was created by dividing total family income by the poverty threshold for family size. A mean ITN was calculated based on data from 1 month through kindergarten (see NICHD EC-CRN, 2001). Mother's level of *education* was collected only at the 1-month interview. The *presence of a husband/partner* in the home was reported in telephone interviews spaced every 3–4 months and operationalized as proportion of epochs 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. *Maternal depression* was assessed at 1, 6, 15, 24, 36, and 54 months, using the Center for Epidemiological Studies Depression Scale (Radloff, 1977), a self-report measure of depressive symptomatology; scores were averaged over time.

A composite measure of parenting was based on maternal sensitivity ratings and scores of the Home Observation for Measurement of the Environment (Caldwell & Bradley, 1984). To assess maternal sensitivity, mother-child interactions were videotaped in semi-structured 15-minute observations at 6, 15, 24, 36, and 54 months. Composite sensitivity scores were created from sums of the different ratings scales (e.g., maternal sensitivity to child nondistress, intrusiveness, positive regard). The HOME was administered during home visits at 6, 15, 36, and 54 months. Information used to score the items (e.g., parental responsiveness, parental involvement, variety in experience) is based on observation and semi-structured interview. The HOME and maternal sensitivity ratings were standardized and averaged within and then across age to create a *parenting quality* composite score.

Results

Two sets of results are presented, the first preliminary, addressing simple bivariate relations among variables, and the second primary, involving prediction of child social functioning using ordinary least square's regression. The level of significance for all analyses was set at $\alpha = .05$, except for tested interactions in the regression analyses where $\alpha = .10$ was used, given challenges

to detecting interaction effects in field studies (McClelland & Judd, 1993).

Preliminary analysis: unadjusted associations

See Table 1 for bivariate correlations between different variables. Most notably, child negativity was not significantly associated with childcare predictor variables (i.e., quality, quantity, or proportion of center care) nor with child outcomes. This independence of the moderator variable (i.e., infant negativity) with predictors and outcomes is a necessary prerequisite for testing differential susceptibility (Belsky et al., 2007).

Primary analyses: temperament \times childcare interactions

After testing all main effects, 3 of 12 tested two-way interactions met the $p < .10$ criteria. All involved childcare quality, meaning that three of four interactions involving quality proved significant, while no evidence emerged consistent with the proposition that the effects of quantity of any type of childcare or of exposure to center care in particular varied as a function of infant negative emotionality. In the interest of space and because all main effects have been reported before and are evident in Table 2, they are neither described nor discussed.

Childcare quality significantly interacted with infant temperament in predicting (1) teacher reported behavior problems ($t = -2.79$, $p = .01$) and (2) social competence at 54 months ($t = 1.97$, $p = .05$) and (3) teacher reported behavior problems ($t = -1.71$, $p = .09$) in kindergarten (see Table 2). To illuminate the nature of the interactions, we plotted regression slopes of childcare quality on behavior problems and social competence at two different values of child temperament. Following Aiken and West (1991), we defined low negativity as 1SD below and high negativity as 1SD above the mean of child temperament. As shown in Figures 1–3, the slopes were increasingly steep from children with low to high negativity for all three observed interactions. The effects of childcare quality on behavior problems at 54 months and in kindergarten were significant for children scoring high in negative emotionality, but not for those low in negativity. Effects of childcare quality on social competence at 54 months did not reach significance regardless of child temperament.

In view of the significant interaction detected in the case of 54-month social competence and the fact that Aiken and West's (1991) recommendations to subdivide the sample at $\pm 1SD$ reflects an arbitrary cut-point, we repeated the analysis for social competence after subdividing the sample at the upper and lower tertile ($n = 534$) instead of the 1SD below and above mean child temperament ($n = 241$); this change revealed a significant association between childcare quality and social competence for the high

Table 1 Unadjusted associations between predictor, moderator, outcome, and control variables

Measures	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Child's gender (1 = Male, 2 = Female)	-													
2. Child's ethnicity (0 = Other, 1 = Caucasian)	-.02													
3. Child temperament	-.03	-.10**												
4. Mother's education	.04	.20**	-.02											
5. Maternal depression	.00	-.20**	.22**											
6. Parenting quality	.07**	.44**	-.12**	.59**										
7. Partner presence (proportion)	-.01	.40**	-.07*	.32**	-.39**									
8. Income-to-needs ratio	.03	.26**	-.07*	.57**	-.32**	.39**								
9. Center childcare (proportion)	.00	-.01	.01	.16**	-.02	.08**	.18**							
10. Childcare quality	.06*	.15**	.01	.21**	-.03	.31**	.22**	-.21**						
11. Childcare quantity (hours/week)	.02	.01	-.03	.14**	-.08**	.06	.41**	.18**	-.10**					
12. Behavior problems at 54 months	.00	-.07	.04	-.18**	.11**	-.22**	-.13**	-.10**	-.10**	.19**				
13. Social competence at 54 months	.14**	.09*	-.03	.20**	-.13**	.26**	.12**	.16**	.11**	-.08*	-.62**			
14. Behavior problems at kindergarten	-.02	-.11**	.00	-.17**	.15**	-.27**	-.21**	-.14**	.09**	-.13**	.07*	-.25**		
15. Social competence at kindergarten	-.02	.15**	-.01	.23**	-.17**	.29**	.22**	.17**	-.05	.14**	-.03	-.24**	-.28**	-.72**

Note. * $p < .05$. ** $p < .01$.

Table 2 Summary of hierarchical regression analyses

Predictor variables	β		
	Behavior problems at 54 months ^a	Social competence at 54 months ^b	Behavior problems at kindergarten ^c
Step 1			
Child gender (1 = Male, 2 = Female)	-.003	.14**	-.002
Child ethnicity (0 = Other, 1 = Caucasian)	.03	-.01	.06#
Child temperament	.03	-.01	-.04
Maternal education	-.12*	.08#	-.01
Maternal depression	.03	-.04	.03
Parenting quality	-.17**	.20**	-.25**
Partner presence	.001	-.03	-.11**
Income-to-needs ratio	.01	.03	.003
Center childcare	.13**	-.01	.09*
Childcare quality	.02	.01	-.02
Childcare quantity	.16**	-.09*	.02
Step 2			
Temperament \times childcare quality	-1.41**	1.02*	-.81#

Note: The displayed coefficients of the variables at step1 represent the values before inclusion of interaction terms at step2.

^a $n = 761$, after Step 2: adjusted $R^2 = .11$ **.

^b $n = 802$, after Step 2: adjusted $R^2 = .09$ **.

^c $n = 915$, after Step 2: adjusted $R^2 = .10$ **.

$p < .10$. * $p < .05$. ** $p < .01$.

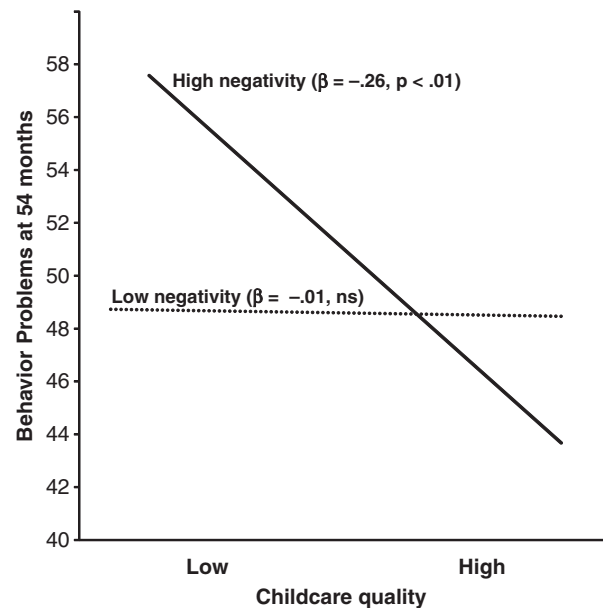


Figure 1 Childcare quality by child temperament interaction predicting teacher reported behavior problems at 54 months

negativity group ($\beta = .15$, $p < .05$) and a non-significant association for the low negativity group ($\beta = .07$, $p = .26$).

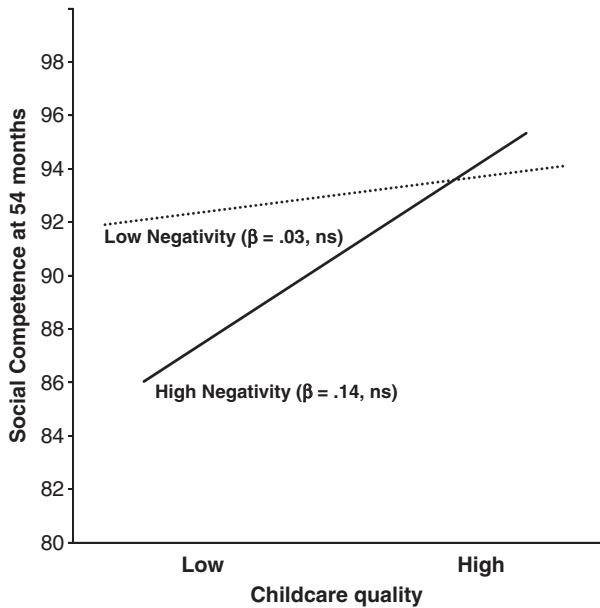


Figure 2 Childcare quality by child temperament interaction predicting teacher reported social competence at 54 months

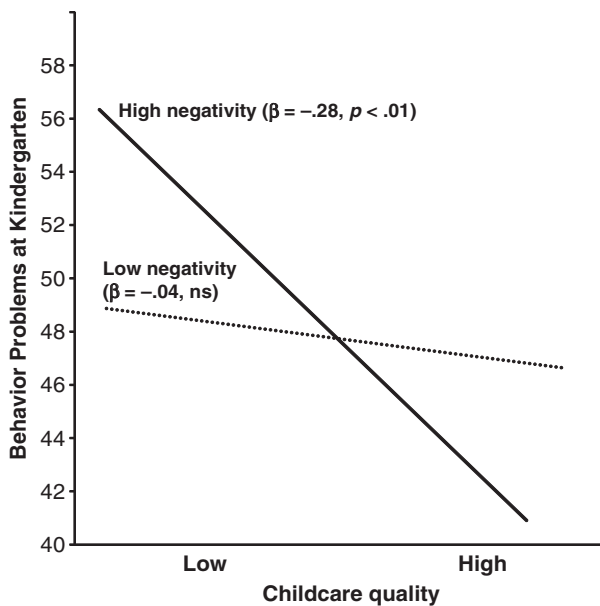


Figure 3 Childcare quality by child temperament interaction predicting teacher reported behavior problems at kindergarten

Discussion

The present study sought to investigate children's differential susceptibility to childcare experience, testing the proposition that highly negative infants would be more affected – both positively and negatively – by childcare experience than less negatively-emotional infants. Recall from the introduction that multiple reports using the NICHD-SECC data have failed to detect (main) effects of childcare quality on social functioning and it was this null result, coupled

with the differential-susceptibility hypothesis, which led to the expectation that should children vary in their susceptibility to childcare, it would be most evident with respect to childcare quality. This is exactly what emerged. Whereas effects of childcare quantity and type did not interact with infant negative emotionality in predicting behavior problems or social competence before and after entrance to school, this was so for childcare quality.

Although quality of childcare had no significant effect on problem behavior and social competence at 54 months or in kindergarten for children with non-difficult/easy temperaments as infants, quality predicted social functioning in the case of children manifesting high levels of negative emotionality or difficult temperaments as infants. In accordance with the differential-susceptibility hypothesis, children with difficult temperaments exhibited both more behavior problems when faced with low quality care and fewer behavior problems when experiencing high quality care. Moreover, we detected effects reflecting differential susceptibility on outcomes representing actual skills rather than just problem behavior: Children with difficult temperaments were rated as more socially competent than children with easy temperaments when exposed to high-quality childcare, but less competent when exposed to low-quality childcare.

The primary findings pertaining to differential susceptibility are consistent not just with growing evidence that more negatively-emotional infants/toddlers appear more affected – in both positive and negative ways – than other children by the quality of parenting they receive (for review, see Belsky, 2005), but also with two recent studies investigating differential susceptibility to parenting focused on the same sample and temperament-moderator variable used in the current inquiry (Bradley & Corwyn, 2008; Dopkins Stright et al., 2008). Hence, infants with difficult temperaments appear more affected by the quality of care they experience – both in and out of the home – than do other young children. Of significance is that the current research, like related research on differential susceptibility (Belsky et al., 2007), indicates that it is not just that negatively-emotional infants are more at risk of succumbing to the adverse effects of problematic rearing environments, but that they also reap a greater benefit from supportive family and childcare environments. As Belsky et al. (2007) noted, a focus exclusively on the adverse effects of at-risk environments on negative outcomes – which has characterized so much work on so-called 'difficult' temperament – may lead to a misrepresentation of the developmental dynamic shaping the functioning of negatively-emotional infants.

Why might difficult or negatively-emotional infants be more susceptible to rearing influences? The characteristics of difficult temperament – low

adaptability, high activity, low emotional regulation – may be indicators of a general heightened sensitivity of the nervous system to environmental stimuli which results in children becoming easily overwhelmed even in just modestly adverse environments, but also in benefiting disproportionately in supportive ones from care that enables them to regulate their proneness to distress and gather information from the world around them. Conceivably, this heightened nervous-system sensitivity reflects a genotypic influence, given documented links between the serotonin transporter polymorphism and newborn negative emotionality (Auerbach et al., 1999). This raises the prospect that research which operationalizes the organismic moderator of experiential influences in genotypic terms (i.e., serotonin transporter polymorphism) or in phenotypic ones (i.e., negative emotionality) may be identifying the very same highly-susceptible individuals.

Consideration of genotypic determinants of negative emotionality and/or heightened susceptibility to rearing does not preclude the possibility that heightened susceptibility may itself be experientially induced. Indeed, this is a prospect raised by Boyce and Ellis (2005) which receives some support from research showing that cortisol-indexed, stress-reactivity in some young mammals is shaped, in part, by fetal experience (Gluckman & Hanson, 2005), as is difficult temperament (Huizink, de Medina, Mulder, Visser, & Buitelaar, 2002; see also Davis et al., 2007).

Especially given that results proved consistent with predictions, it is important to highlight limitations of this investigation. Not only was the design correlational, thereby limiting causal inferences, but the fact that the sample was not nationally representative and suffered non-random attrition and missing data are also limiting factors. Of note, too, is that critical variables were based exclusively on reports of mothers (infant temperament) and caregivers/teachers (child outcomes). Given that such measurements can be affected by raters' well-being, the study would have been strengthened by the availability of more reliable and valid observational data. Indeed, had the NICHD SECC been originally designed to test the differential-susceptibility hypothesis regarding the moderating effects of negative emotionality, specific behavioral assessments of these constructs could have been included in the protocol. Finally, however theoretically important, interaction effects detected were small.

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References

- Achenbach, T. (1991). *Manual for the Child Behavior Checklist/4–18 and 1991 Profile*. Burlington, VT: Author.
- Aiken, L.S., & West, S.G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.
- Auerbach, J., Geller, V., Lezer, S., Shinwell, E., Belmaker, R.H., Levine, J., et al. (1999). Dopamine D4 receptor (D4DR) and serotonin transporter promoter (5-HTTLPR) polymorphisms in the determination of temperament in 2-month-old infants. *Molecular Psychiatry*, 4, 369–373.
- Belsky, J. (1986). Infant day care: A cause for concern? *Zero to Three*, 7, 1–7.
- Belsky, J. (1997). Variation in susceptibility to rearing influences: An evolutionary argument. *Psychological Inquiry*, 8, 182–186.
- Belsky, J. (2001). Emanuel Miller Lecture: Developmental risks (still) associated with early child care. *Journal of Child Psychology and Psychiatry*, 42, 845–859.
- Belsky, J. (2005). Differential susceptibility to rearing influences: An evolutionary hypothesis and some evidence. In B. Ellis, & D. Bjorklund (Eds.), *Origins of the social mind: Evolutionary psychology and child development* (pp. 139–163). New York: Guilford.
- Belsky, J., Bakermans-Kranenburg, M.J., & van Ijzendoorn, M.H. (2007). For better and for worse: Differential susceptibility to environmental influences. *Current Directions in Psychological Science*, 16, 300–304.
- Boyce, W.T., & Ellis, B.J. (2005). Biological sensitivity to context: I. An evolutionary-developmental theory of the origins and functions of stress reactivity. *Development and Psychopathology*, 17, 271–301.
- Bradley, R.H., & Corwyn, R.F. (2008). Infant temperament, parenting, and externalizing behavior in first grade: A test of the differential susceptibility

- hypothesis. *Journal of Child Psychology and Psychiatry*, 49, 124–131.
- Bradley, R.H., & Vandell, D.L. (2007). Child care and the well-being of children. *Archives of Pediatrics and Adolescent Medicine*, 161, 669–676.
- Burchinal, M.R., Peisner-Feinberg, E., Bryant, D.M., & Clifford, R. (2000). Children's social and cognitive development and child-care quality: Testing for differential associations related to poverty, gender, or ethnicity. *Applied Developmental Science*, 4, 149–165.
- Caldwell, B., & Bradley, R.H. (1984). *Home observation for measurement of the environment*. Little Rock: University of Arkansas Press.
- Carey, W.B., & McDevitt, S.C. (1978). Revision of the Infant Temperament Questionnaire. *Pediatrics*, 61, 735–739.
- Caspi, A., McClay, J., Moffitt, T.E., Mill, J., Martin, J., Craig, I.W., et al. (2002). Role of genotype in the cycle of violence in maltreated children. *Science*, 297, 851–854.
- Caspi, A., Moffitt, T.E., Newman, D.L., & Silva, P.A. (1996). Behavioral observations at age 3 years predict adult psychiatric disorders. Longitudinal evidence from a birth cohort. *Archives of General Psychiatry*, 53, 1033–1039.
- Caspi, A., Sugden, K., Moffitt, T.E., Taylor, A., Craig, I.W., Harrington, H., et al. (2003). Influence of life stress on depression: Moderation by a polymorphism in the 5-HTT gene. *Science*, 301, 386–389.
- Clarke-Stewart, A. (1988). The 'effects' of infant day care reconsidered: Risk for parents, children, and researchers. *Early Childhood Research Quarterly*, 3, 293–318.
- Côté, S.M., Boivin, M., Nagin, D.S., Japel, C., Xu, Q., Zoccolillo, M., et al. (2007). The role of maternal education and nonmaternal care services in the prevention of children's physical aggression problems. *Archives of General Psychiatry*, 64, 1305–1312.
- Côté, S.M., Borge, A.I., Geoffroy, M.C., Rutter, M., & Tremblay, R.E. (2008). Nonmaternal care in infancy and emotional/behavioral difficulties at 4 years old: Moderation by family risk characteristics. *Developmental Psychology*, 44, 155–168.
- Crockenberg, S.C., & Leerkes, E.M. (2005). Infant temperament moderates associations between child-care type and quantity and externalizing and internalizing behaviors at 2½ years. *Infant Behavior & Development*, 28, 20–35.
- Davis, E.P., Glynn, L.M., Schetter, C.D., Hobel, C., Chiciz-Demet, A., & Sandman, C.A. (2007). Prenatal exposure to maternal depression and cortisol influences infant temperament. *Journal of the American Academy of Child and Adolescent Psychiatry*, 46, 737–746.
- Deater-Deckard, K., Pinkerton, R., & Scarr, S. (1996). Child care quality and children's behavioral adjustment: A four-year longitudinal study. *Journal of Child Psychology and Psychiatry*, 37, 937–948.
- Dettling, A.C., Parker, S.W., Lane, S., Sebanc, A., & Gunnar, M.R. (2000). Quality of care and temperament determine changes in cortisol concentrations over the day for young children in childcare. *Psychoneuroendocrinology*, 25, 819–836.
- Dmitrieva, J., Steinberg, L., & Belsky, J. (2007). Child-care history, classroom composition, and children's functioning in kindergarten. *Psychological Science*, 18, 1032–1039.
- Dopkins Stright, A., Cranley Gallagher, K., & Kelley, K. (2008). Infant temperament moderates relations between maternal parenting in early childhood and children's adjustment in first grade. *Child Development*, 79, 186–200.
- Gluckman, P., & Hanson, M. (2005). *The fetal matrix: Evolution, development and disease*. Cambridge: Cambridge University Press.
- Gresham, F., & Elliott, S. (1990). *Social skills rating system*. Circle Pines, MN: American Guidance Service.
- Huizink, A.C., de Medina, P.G., Mulder, E.J., Visser, G.H., & Buitelaar, J.K. (2002). Psychological measures of prenatal stress as predictors of infant temperament. *Journal of the American Academy of Child and Adolescent Psychiatry*, 41, 1078–1085.
- Lamb, M.E., & Ahnert, L. (2006). Nonparental child care: Context, concepts, correlates, and consequences. In K.A. Renninger, I.E. Sigel, W. Damon, & R.M. Lerner (Eds.), *Handbook of child psychology, 6th edn: Vol. 4, Child psychology in practice* (pp. 950–1016). Hoboken, NJ: John Wiley & Sons.
- Levine, S., Elzey, F.F., & Lewis, M. (1969). *California preschool social competency scale*. Palo Alto, CA: Consulting Psychologists Press.
- Loeb, S., Bridges, M., Bassok, D., Fuller, B., & Rumberger, R.W. (2007). How much is too much? The influence of preschool centers on children's social and cognitive development. *Economics of Education Review*, 26, 52–66.
- Loeb, S., Fuller, B., Kagan, S.L., & Carrol, B. (2004). Child care in poor communities: Early learning effects of type, quality, and stability. *Child Development*, 75, 47–65.
- Love, J.M., Harrison, L., Sagi-Schwartz, A., Van IJzendoorn, M.H., Ross, C., Ungerer, J.A., et al. (2003). Child care quality matters: How conclusions may vary with context. *Child Development*, 74, 1021–1033.
- McClelland, G.H., & Judd, C.M. (1993). Statistical difficulties of detecting interactions and moderator effects. *Psychological Bulletin*, 114, 376–390.
- McGurk, H., Caplan, M., Hennessy, E., & Moss, P. (1993). Controversy, theory and social context in contemporary day care research. *Journal of Child Psychology and Psychiatry*, 34, 3–23.
- NICHD Early Child Care Research Network. (2001). Nonmaternal care and family factors in early development: An overview of the NICHD Study of Early Child Care. *Applied Developmental Psychology*, 22, 457–492.
- NICHD Early Child Care Research Network. (2002). Early child care and children's development prior to school entry: Results from the NICHD Study of Early Child Care. *American Educational Research Journal*, 39, 133–164.
- NICHD Early Child Care Research Network. (2003). Does amount of time spent in child care predict socioemotional adjustment during the transition to kindergarten? *Child Development*, 74, 976–1005.

- NICHD Early Child Care Research Network. (2005a). *Child care and child development: Results of the NICHD Study of Early Child Care and Youth Development*. New York: Guilford Press.
- NICHD Early Child Care Research Network. (2005b). Early Child care and children's development in the primary grades: Follow-up results from the NICHD Study of Early Child Care. *American Educational Research Journal*, 42, 537–570.
- Peisner-Feinberg, E.S., Burchinal, M.R., Clifford, R.M., Culkin, M.L., Howes, C., Kagan, S.L., et al. (2001). The relation of preschool child-care quality to children's cognitive and social developmental trajectories through second grade. *Child Development*, 72, 1534–1553.
- Phillips, D., McCartney, K., & Scarr, S. (1987a). Child-care quality and children's social development. *Developmental Psychology*, 23, 537–543.
- Radloff, L.S. (1977). The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, 1, 385–401.
- Sussman, A., Crowell, N., Phillips, D., Hane, A., & Fox, N.A. (in press). Temperament and young children's experience of child care quality. *Early Childhood Research Quarterly*.
- Taylor, S.E., Way, B.M., Welch, W.T., Hilmert, C.J., Lehman, B.J., & Eisenberger, N.I. (2006). Early family environment, current adversity, the serotonin transporter promoter polymorphism, and depressive symptomatology. *Biological Psychiatry*, 60, 671–676.
- Volling, B.L., & Feagans, L.V. (1995). Infant day care and children's social competence. *Infant Behavior and Development*, 18, 177–188.

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