Published in final edited form as:

J Fam Psychol. 2012 June ; 26(3): 391–399. doi:10.1037/a0028331.

Socioeconomic Risk Moderates the Link between Household Chaos and Maternal Executive Function

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Abstract

We examined the link between household chaos (i.e., noise, clutter, disarray, lack of routines) and maternal executive function (i.e., effortful regulation of attention and memory), and whether it varied as a function of socioeconomic risk (i.e., single parenthood, lower mother and father educational attainment, housing situation, and father unemployment). We hypothesized that: 1) higher levels of household chaos would be linked with poorer maternal executive function, even when controlling for other measures of cognitive functioning (e.g., verbal ability), and 2) this link would be strongest in the most socioeconomically distressed or lowest-socioeconomic status households. The diverse sample included 153 mothers from urban and rural areas who completed a questionnaire and a battery of cognitive executive function tasks and a verbal ability task in the laboratory. Results were mixed for hypothesis 1, and consistent with hypothesis 2. Two-thirds of the variance overlapped between household chaos and maternal executive function, but only in families with high levels of socioeconomic risk. This pattern was not found for chaos and maternal verbal ability, suggesting that the potentially deleterious effects of household chaos may be specific to maternal executive function. The findings implicate household chaos as a powerful statistical predictor of maternal executive function in socioeconomically distressed contexts.

Keywords

parenting; executive function; environment; socioeconomic status

Healthy functioning for parents and youth alike involves individual's personal attributes (e.g., personality, cognitive functions) operating within social relationships that are themselves embedded in ecological contexts in the home and beyond (Bronfenbrenner & Ceci, 1994). Furthermore, these ecological contexts can powerfully constrain or modulate the processes that link stressors to individuals' resilient or maladaptive functioning (Sameroff, 2010; Wright & Masten, 2005). This bio-ecological, risk-resilience theoretical framework provides the foundation for the current investigation of connections between socioeconomic risk factors, household "chaos" (e.g., noise, distractions, disarray), and maternal cognitive self-regulation of attention and memory.

Research has shown that a calm and predictable household environment is less stressful and more optimal for the healthy development and functioning of all family members. Higher levels of chronic household chaos predict poorer cognitive and social-emotional outcomes for children and adolescents—an effect that is mediated in part by higher levels of harsh and distressed parenting (Coldwell, Pike, & Dunn, 2006; Evans & Wachs, 2009). The literature on household chaos points to strong links with socioeconomic stressors, but the mechanisms

by which household chaos influence and are influenced by parenting behavior and functioning across the socioeconomic spectrum are not well understood. To address this gap, in the current study we focused on the link between household chaos and maternal cognitive self-regulation of attention and memory (i.e., executive function), given the importance of executive function to well-regulated caregiving and its susceptibility to the effects of stress and fatigue that are prominent features of life in chaotic households. To this end, we tested two hypotheses: 1) that higher levels of household chaos would be associated with poorer maternal executive function, and 2) the link between chaos and maternal executive function would be strongest in households with the most socioeconomic stressors.

Household Chaos and Parent Regulation

Living in a calm predictable home is crucial to healthy family functioning and optimal child development. However, many children and adolescents grow up in homes that are not well regulated. Household chaos is operationalized as high levels of noise and distractions, human crowding and traffic, low levels of predictability in the environment, and lack of family routines—indicators that can be observed or reliably reported by parents (Matheny, Wachs, Ludwig, & Phillips, 1995). There is wide variability in chaos between homes that is stable over time and that covaries with family socioeconomic status or risk factors (for reviews, see Evans, 2006; Evans & Wachs, 2009; Wachs & Çorapçı, 2003). Even after controlling for socioeconomic risk, more chaos is associated with higher levels of parental depression and stress (Evans et al., 1998; Pike, Iervolino, Eley, Price, & Plomin, 2006) and harsher caregiving (Dumas et al., 2005; Valiente, Lemery-Chalfant, & Reiser, 2007). This takes its toll on children, with a number of studies showing deleterious effects on children's cognitive and scholastic performance and behavioral adjustment (Asbury, Wachs, & Plomin, 2005; Coldwell, Pike, & Dunn, 2006; Deater-Deckard et al., 2009; Dumas et al., 2005; Petrill, Pike, Price, & Plomin, 2004; Pike et al., 2006).

Although it is clear that household chaos is connected to harsh and distressed caregiving through stress processes, the mechanisms that explain this connection are not well understood. Identifying these mechanisms could lead to innovations in parenting education and treatment that might mitigate the deleterious effects of chaos on caregiving and children's outcomes. Our goal in the current study was to conduct a novel investigation of the potential link between chaos and maternal executive function. Executive function represents the cognitive modulation of attention and memory that serves effective self-regulation of a wide variety of cognitive, emotional, and behavioral responses to the environment (Friedman et al., 2008). Maternal executive function is important to sensitive, nonreactive caregiving. Several decades of experimental and correlational animal studies have shown that a variety of cognitive skills are involved in the provision of adequate caregiving of offspring, with executive function being particularly important (Barrett & Fleming, 2011). In human studies, over two decades ago Wahler and Dumas (1989) highlighted attentional aspects of maternal executive function in a heuristic framework that emphasized maternal distractibility as a key factor in harsh reactive caregiving behavior in the face of stressors—even among parents who were otherwise well equipped for optimal parenting in terms of their childrearing beliefs and skills.

More recently, quasi-experimental research has shown that maternal working memory (but not verbal ability, abstract reasoning, or quantitative reasoning) was a critical modulator of parental reactive negativity in the face of angry, noncompliant and impulsive child behavior (Deater-Deckard, Sewell, Petrill, & Thompson, 2010; see also Lee et al., 2010, for a closely related molecular genetic study). Specifically, mothers with poorer executive function were more likely to show reactive harsh parenting behavior when the child's behavior was challenging. It is during such situations that an individual must effortfully attend to and

mentally work with multiple pieces of information retrieved from memory and perceived in the situation, to regulate her or his own thoughts and emotions in order to generate behaviors that are appropriate and nonreactive (Lemerise & Arsenio, 2000; Ochsner & Gross, 2008).

To our knowledge there is no previous study that has examined the link between chaos and maternal executive function. However, there are studies that have shown a modest to moderate correlation between higher levels of chaos and lower levels of general cognitive test performance—tests that include tasks requiring executive attention and memory (Deater-Deckard et al., 2009; Engle & Kane, 2004). The potential connection between higher levels of chaos and poorer executive function may be explained by some of the features of chaotic environments. These environments lack predictability and have many sources of distraction and noise (e.g., stereos, TVs, exterior noises from traffic) that lead to chronic stress and fatigue, psychologically and physiologically (for an overview see Evans & Wachs, 2009). Experiments have shown that it is under these kinds of conditions—distraction, stress, and fatigue—that executive function capacity is impaired (Schoofs, Wolf, & Smeets, 2009; Boksem, Meijman, & Lorist, 2005). Based on this prior evidence, our first hypothesis was that higher levels of household chaos would be associated with poorer maternal executive function. Furthermore, given that executive function positively covaries with verbal intelligence at behavioral and neurological levels of analysis (Barbey et al., in press), when testing this hypothesis we statistically controlled maternal verbal ability (measured as receptive vocabulary) to more rigorously isolate effects that might be specific to executive function.

The Role of Socioeconomic Stress

The investigation of a potential link between household chaos and maternal executive function also requires consideration of family socioeconomic factors. Socioeconomic risk factors are broad indicators of families' living circumstances that represent lack of access to resources that support good health and family functioning. These risk factors can cause stress, illness and maladjustment, particularly when the risk factors accumulate in chronically poor living circumstances (Adler & Snibbe, 2003; Jayakody & Stouffer, 2000). Although there are many ways to measure this domain of family risk status, key dimensions include parental educational attainment, employment, and adequate stable income (Grusky, 2001).

Household chaos is more prevalent and chronic in households that have more socioeconomic risks. In addition, individuals in these households are more susceptible to the adverse effects of chaos, compared to those living in socioeconomically advantaged homes (Brody & Flor, 1997; Coldwell et al., 2006; Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005; Valiente, Lemery-Chalfant, & Reiser, 2007). It is plausible that it is under such circumstances that high levels of chaos will be most strongly connected to poorer parental self-regulation (Fiese, Wamboldt, & Anbar, 2005). This idea is consistent with a broader finding—that the effect of stressors on health and functioning may be strongest for those with the most socioeconomic risks and weakest for those with the most socioeconomic advantages (Eller, Kristiansen, & Hansen, 2011; Taylor & Seeman, 1999). Therefore, we also tested a second hypothesis: that the anticipated association between household chaos and poorer executive function (hypothesis 1) would be moderated by level of family socioeconomic risk, with the strongest association found in the most socioeconomically distressed households.

In the current study we measured five indicators that directly or indirectly assess education, employment and income while also capturing some of the broader variance in socio-cultural processes that are important for psychological research (American Psychological

Association, 2007). As described in more detail in the Methods section, we constructed a socioeconomic multiple risk variable from the sum of five socioeconomic risks. These included three commonly used risk factors: low mother education and low father education (i.e., a high school diploma or less), and father unemployment. As a fourth risk factor, we also included living in home that was not a detached single family house (i.e. apartment, townhouse, trailer/mobile home). This distinction in housing circumstances is associated with features of the ecology of the home and neighborhood that predict health and functioning, beyond measures of parental employment, income and education (Diez-Roux et al., 2001). The fifth risk factor was single mother status, because it is the family structure attribute with the strongest links to family poverty and barriers to employment and education (American Psychological Association, 2007).

Based on this operationalization of socioeconomic risk, families could have from zero to five risk factors. A multiple risk variable is advantageous because it uses a continuous ratio scale that is readily interpretable, and it efficiently represents the cumulative statistical effect of its multiple covarying indicators (e.g., Sameroff, Seifer, Barocas, Zax, & Greenspan, 1987). To test the first and second hypotheses, we estimated the socioeconomic risk variable's main effect and interaction with chaos in the prediction of maternal executive function.

Methods

Participants

The initial sample included 153 mother-child pairs with complete task and questionnaire data ($n = 140$ with outliers removed, as described below). Mothers were 21 to 49 years old ($M = 32.74$, $SD = 6.29$), and the target children were 33 to 88 months old ($M = 57.57$, $SD = 15.59$; 50% female). The majority of the sample was recruited through a laboratory in a small urban area ($n = 109$). They were recruited through community agencies and organizations and advertisements (e.g., flyers given to parents through publicly funded preschools and schools; flyers placed up in common areas throughout the community; university website and email announcements). Potential participants were given a phone number to contact the project coordinator with any questions they might have about participating. Participants received an honorarium. This procedure led to 112 mothers with children in the correct age range scheduling a visit. Of these, three completed part but not all of the data collection protocol. We also invited mothers in a cohort of families in an ongoing longitudinal community study to participate in a visit to a nearby rural university laboratory ($n = 44$). This cohort included 60 mothers; of these, 11 chose not to participate and five completed part but not all of the data collection protocol. Study "site" (urban = 1, rural university = 2) was included as a covariate in analyses.

The sample was ethnically and socioeconomically diverse, and broadly representative of the population in this region of the state. Thirty-six percent of mothers reported being single parents. Race was reported by mothers regarding both biological parents (mother/father): 74/68% Caucasian, 12/18% African American, 1/2% Asian, 8/7% multiple races, 1/1% other, and 4/4% not specified. Four percent of mothers and 2% of fathers were reported to be Hispanic. For the region the population percentages in 2007 were 82% Caucasian, 11% African American, 3% Asian, and 4% multiple races (from the 2005–2007 American Community Survey data, located at the US Census Bureau website, <http://www.census.gov/acs>). Sixty-nine percent of the mothers were cohabiting or married and living with the child's biological father, 6% were separated or divorced from the child's father following a marriage, and the remaining 25% were single mothers who had not married the father. For mother/father education: 22/31% high school diploma/GED or less; 28/29% some college or an Associate's degree; 30/19% 4-year degree; and 20/20% post-

graduate degree. For the region the population percentages in 2007 for all adult women/men were 41/43% diploma/GED or less; 27/25% some college or Associates degree; 19/17% 4-year degree; and 12/14% post-graduate degree (also from the 2005–2007 American Community Survey data, <http://www.census.gov/acs>). Twenty-five percent lived in an apartment, duplex, townhouse or mobile home and 75% lived in a detached single family home. Eighteen percent of the fathers were unemployed.

Measures

Socioeconomic risk—We computed a socioeconomic risk index by summing across five indicators. These were, in order from most to least frequent: single mother [1 (38% of sample), vs. 0 = married or cohabiting with child's father], low paternal education [1 = high school/GED or less (30% of sample), vs. 0 = some college or higher education], housing [1 = apartment, townhouse, duplex, mobile home (26% of sample) vs. 0 = separated single family home], low maternal education [1 = high school/GED or less (22% of sample), vs. 0 = some college or higher education], and paternal unemployment [1 = unemployed (18% of sample), vs. 0 = employed]. These risk indicators all covaried, with Spearman rho coefficients ranging from .26, $p < .01$ to .44, $p < .001$. The resulting distribution of the summed multiple risk variable was: 0 risks ($n = 64$ or 41.8% of sample), 1 ($n = 34$, 22.2%), 2 ($n = 19$, 12.4%), 3 ($n = 19$, 12.4%), 4 ($n = 10$, 6.5%), 5 ($n = 7$, 4.6%). Figure 1 shows the prevalence of each risk indicator as a function of overall multiple risk status. There appeared to be fairly linear increases in the prevalence of each risk factor as a function of overall risk status, with the exception of father unemployment which jumped from 10–21% for those with three or fewer risks to 80% for those with four risks.

Household Chaos—Mothers completed a modified version of the reliable and validated Chaos, Hubbub and Order Scale (CHAOS, Matheny et al., 1995). The modified version has been used in several studies in the UK (Coldwell et al., 2006, $\alpha = .56$; Pike et al., 2006, $\alpha = .63$) and the US (Deater-Deckard et al., 2009, inter-rater and test-retest reliabilities in .6 to .8 range). This modified version includes six items from the original instrument, scored using a 5-point Likert-type scale rather than the original instrument's binary (yes/no) scale. The six items are: "I have a regular morning routine" (reverse scored), "You can't hear yourself think in our home", "It's a real zoo in our home", "We are usually able to stay on top of things" (reverse scored), "There is usually a television turned on somewhere in our home", and "The atmosphere in our house is calm" (reverse scored). Scale reliability was acceptable and consistent with prior studies ($\alpha = .65$).

Maternal Executive Function—We used tasks (counterbalanced) and questionnaires that captured aspects of executive attention and memory (Engle & Kane, 2004; Davis & Keller, 1998; Heaton & PAR Staff, 2003). To increase measurement reliability we computed a composite z-score. Mothers also completed the PPVT-4 (Dunn & Dunn, 2007) as a measure of verbal ability. The PPVT age standardized score was used as a covariate in the analyses.

The Stroop color-word task was administered on a computer (Stroop, 1935). Participants named the color of the ink of color words in which the actual color of the letters and the color being named are congruent (e.g., "red" written in red ink) or incongruent (e.g., "red" written in yellow ink), following an initial reading trial in which the participant simply read the color of the ink of a series of Xs. We used a set of 20 words with mixed incongruent and congruent stimuli (which minimizes practice effects), and mothers' scores on the task were calculated as the average reaction time for correct responses, $M = 1,667.27$ ms, $SD = 781.17$ ms.

A computerized version of the Wisconsin Card Sorting Test (WCST) involved presentation of four stimulus cards with different colors, quantities, and shapes (Heaton & PAR Staff, 2003). Mothers attempted to match a stack of 64 (at the rural university lab) or 128 (at the urban lab) cards to the original stimulus cards according to a rule which they had to ascertain (i.e., either by color, quantity or shape). The matching rule changed several times and the participant had to infer the new rule based on feedback from the computer regarding correct vs. incorrect responses. We used the number of perseveration errors per 64 trials which represents mistakes made by continuously using the same incorrect matching rule (i.e., difficulty inhibiting the dominant practiced response) even after receiving feedback indicating that the rule was no longer correct, $M = 6.67$ errors, $SD = 5.01$ errors.

A computerized version of the Tower of Hanoi was used to measure mothers' problem solving abilities involving executive function and prefrontal activation (Davis & Keller, 1998). The task involved moving three disks of different sizes to a target peg in the same order, using two rules: only one disk can be moved each turn, and larger disks cannot be placed on smaller disks. Time to completion (up to 60 secs) was used as the score for the task, $M = 38.48$ secs, $SD = 16.57$ secs; those who did not finish received a score of 60 secs.

In addition, an experimenter administered a backward digit span task. The experimenter read a seemingly random series of single-digit numbers (0–9) and the participant attempted to reproduce the sequence in reverse. Following a practice trial with two sets of two digits, the task began with a four digit sequence and then added one more digit in each subsequent trial. Mothers had two chances to correctly reproduce the new digit sequence in reverse. The task ended when the mother provided incorrect responses on both chances. The last correct trial was used as the mother's backward digit span score, $M = 5.09$ digits, $SD = 2.17$ digits.

The first principal component among the four task scores (with Stroop, Wisconsin Card Sorting Test, and Tower of Hanoi scores reversed so that higher scores represented better performance) explained 41% of the variance ($\lambda = .57$ to $.75$). The four scores were standardized and averaged, with the average score standardized again to yield a composite task performance z-score that was widely and normally distributed.

Mothers also rated their own inhibitory control (seven items, $\alpha = .50$) and attention control (five items, $\alpha = .75$) using these two scales from the Adult Temperament Questionnaire Short Form (Evans & Rothbart, 2007). Although the reliability of the inhibitory subscale is relatively low, we decided to include it as a component of self-reported executive function because difficulty in inhibiting prepotent responses arising from goal irrelevant distraction is an important aspect of executive function. To address this reliability deficit and to get a more comprehensive and reliable score for self-reported executive function, we averaged the inhibitory control and attention control scales, $r(152) = .48$, $p < .001$, to represent self-reported executive function (12 items, $\alpha = .74$), $M = 4.36$, $SD = 0.89$. This score was standardized for subsequent analyses.

When possible, it is preferable to use multi-informant composite scores for constructs, because these typically have better predictive validity and yield effects that are more likely to be replicated than those based on single informants and limited sets of indicators (Mathijssen et al., 1998; Nunnally & Bernstein, 1994; Rushton, Brainerd, & Pressley, 1983). To this end, we computed a composite score representing maternal executive function that integrated data from the executive function task performance score and the maternal self-report score. In the full sample, these two scores were modestly correlated, $r(152) = .17$, $p < .05$. However, through the examination of potential bivariate outliers (i.e., mothers who had highly discrepant performance-based vs. self-reported executive function scores) it became clear that the covariation between task-based and self-reported executive function

was attenuated due to 13 mothers with fairly large performance/self-report discrepancies of more than 2.2 SD. With these 13 participants set aside from subsequent analyses ($n = 140$), task-based and self-reported executive function scores were moderately correlated, $r(139) = .41$, $p < .01$. The task and self report z-scores were averaged and standardized to yield an overall composite z-score that was used in subsequent analyses. It is worth noting that the results reported below were very similar to the results if the 13 bivariate outlier participants were included.

Results

For the data analysis plan, we first computed descriptive statistics and bivariate correlations. This was followed by estimation of a hierarchical multiple regression equation predicting maternal executive function, to test the hypotheses that: 1) chaos would be associated with poorer executive function (tested as a statistical predictor), and that 2) this effect would be strongest for mothers with the highest levels of socioeconomic risk (tested as a two-way statistical interaction between chaos and socioeconomic risk, with post-hoc probing of the interaction). If the anticipated statistical interaction between socioeconomic risk and chaos was significant, we planned post-hoc probing of the interaction by estimating correlations between chaos and executive function, separately for mothers at each level of socioeconomic risk. This would allow us to test whether the association was strongest at the highest levels of socioeconomic risk.

Descriptive Statistics

We began by estimating descriptive statistics and bivariate correlations for the study variables (Table 1, listwise deletion of missing data, $n = 136$), to better understand the distributions in and patterns of covariance between the study variables before testing the study hypotheses. The distribution of maternal PPVT scores approximated the population distribution, with an average score just above 100 and a standard deviation approaching 15 points. The average household had 1.26 of the five socioeconomic risk factors present, with wide distribution indicated by a standard deviation of nearly 1.5 risk factors. Household chaos was somewhat skewed toward the “calmer” end of the distribution, with the mean (2.26) being below the mathematical midpoint of 3.0 on the 5-point scale for the instrument. However, the distribution of household chaos scores spanned nearly the entire range of the measurement scale, with one standard deviation represented as two-thirds of a point on its 5-point scale. The executive function composite z-score was widely and normally distributed.

In regard to correlations, mothers who participated at the rural university site had fewer socioeconomic risks and also had higher PPVT scores compared to those at the urban site. Better performance on the PPVT was associated with fewer socioeconomic risks. Higher PPVT scores and lower socioeconomic risk scores both were associated with lower levels of household chaos, and better maternal executive function. This pattern of correlations was consistent with the literature, indicating links between more socioeconomic risk, poorer cognitive performance, and more household chaos.

Testing Hypotheses

Next, we turned to analyses to test hypothesis 1—that higher levels of household chaos would be associated with poorer maternal executive function. Consistent with this expectation, the bivariate correlation between chaos and maternal executive function (see Table 1) was significant, but modest in magnitude. To more rigorously test this hypothesized association between chaos and executive function (i.e., in the context of other correlated variables such as site, PPVT, and socioeconomic risk), and to also test the hypothesized interaction between chaos and socioeconomic risk, we estimated a hierarchical regression

equation (predictors centered) predicting variance in the maternal executive function composite z-score from: step 1, laboratory site (1 = urban, 2 = rural university) and PPVT score as covariates; step 2, socioeconomic risk and household chaos; step 3, risk X chaos interaction (see Table 2).

The full regression equation explained 31% of the variance in maternal executive function, $F(5, 130) = 7.93, p < .001$. Step 1 was significant (20% variance), and step 2 was significant (5% more variance). Significant main effects for site, PPVT, and socioeconomic risk were consistent with the correlations described above. It is noteworthy that the hypothesized main effect of household chaos for maternal executive function—detected as a significant bivariate correlation as noted above and in Table 1—no longer was significant with the inclusion of the other covarying variables including study site, maternal PPVT score, and family socioeconomic risk. However, consistent with the hypothesis, the two-way interaction between socioeconomic risk and household chaos (step 3 of the equation) was significant and explained an additional 6% of the variance.¹

Post-hoc Probing of the Statistical Interaction

To probe the two-way interaction and test whether the link between chaos and maternal executive function was strongest for mothers with the most socioeconomic risks as we hypothesized, we estimated correlations between chaos and executive function for each level of socioeconomic risk. We also estimated partial correlations controlling for PPVT (since it was a significant covariate in the regression equations), but these were very similar to the zero-order correlations that we computed and have presented in Figure 2 so they are not reported. Consistent with the second hypothesis, chaos was significantly and substantially correlated with poorer executive function for families at the highest levels of socioeconomic risk (i.e., the dark bars in Fig. 2, representing significant correlations of about $-.80$ for those with four or all five risks), but was only modestly and not significantly correlated at lower levels of risk (i.e., the light bars in Fig. 2, representing nonsignificant correlations in the $.1$ to $-.2$ range for those with three or fewer risks).

Discussion

Family and parenting processes operate within ecological contexts that can modulate the processes or mechanisms that connect stressors and individual functioning (Bronfenbrenner & Ceci, 1994; Sameroff, 2010; Wright & Masten, 2005). In the current investigation, we examine chaotic home environments (e.g., noise, distractions, crowding, people traffic, lack of routines) that are stressful for all family members. Chaos can produce serious and lasting deleterious consequences for a wide range of children's developmental outcomes, in part through its negative impact on parental functioning and caregiving behavior (Asbury et al., 2005; Coldwell et al., 2006; Deater-Deckard et al., 2009; Dumas et al., 2005; Petrill et al., 2004; Pike et al., 2006; Valiente et al., 2007; for a comprehensive overview see Evans & Wachs, 2009). Our goal was to examine a potential mechanism by which chaos might influence and be influenced by parenting stress and behavior, to build knowledge that might improve parenting prevention and intervention efforts that promote healthy family functioning and child development. To this end, we focused on maternal executive function.

¹Note that we statistically predicted the task and self report composite scores separately. The SES $\times$ chaos interaction remained significant in both cases, explaining 3% (self report composite) and 6% (task composite) of the variance. In addition, to test whether the effects were present for cognitive ability more broadly (rather than being specific to executive function), we swapped PPVT and executive function in the regression equation so that executive function was a predictor and SES and chaos main and interactive effects statistically predicted PPVT. The interaction term was negligible and nonsignificant as a predictor of PPVT score, suggesting that the effect was specific to executive function.

Hypothesis 1: Chaos and Executive Function

Our rationale for examining executive function was that it is an important component of calm nonreactive parenting that is susceptible to impairment by stress, fatigue, and distraction (Barrett & Fleming, 2011; Boksem et al., 2005; Deater-Deckard et al., 2010; Schoofs et al., 2009; Wahler & Dumas, 1989)—conditions that are most prevalent in chaotic households. The first hypothesis was that higher levels of chaos would be associated with poorer maternal executive function. There was mixed evidence in support of this hypothesis. The bivariate correlation between chaos and maternal executive function was negative and statistically significant, $r = -.20$ (see Table 1). However, the magnitude of this correlation was modest, particularly when compared to the larger correlation between socioeconomic risk and executive function, $r = -.40$ (see Table 1). Furthermore, when socioeconomic risk and mother PPVT scores were statistically controlled in a regression equation predicting maternal executive function, chaos was no longer a significant predictor.

The mixed results may not be surprising, given the well established correlation between chaos and socioeconomic status. That literature suggests a causal role of poverty and related barriers to access to social and economic resources in the etiology of household chaos (Brody & Flor, 1997; Evans et al., 2005). Thus, household chaos may be implicated in poorer executive function for mothers, but its modest effect overlaps with the effects of other covarying risk factors such as socioeconomic risk and lower verbal ability. Although studies of household chaos have demonstrated that it statistically predicts poorer child and adolescent outcomes beyond the variance accounted for by other risk factors, the effects that are unique to chaos tend to be modest in magnitude (Deater-Deckard et al., 2009). This would appear to be the case for maternal outcomes as well, if the current study's findings are replicated.

Hypothesis 2: Socioeconomic Risk as a Moderator

However, what if the mechanism that connects chaos and maternal executive function depends on the family's level of socioeconomic stress? Perhaps chaos operates interactively, not additively, with the effects of socioeconomic risk—a premise that would be consistent with bio-ecological and risk-resilience theories of development and family functioning (Sameroff, 2010; Wright & Mastern, 2005). This could be the case, given theory and research indicating that the effects of stressors are stronger for those with fewer socioeconomic and covarying psychosocial resources (Taylor & Seeman, 1999). Therefore, our second hypothesis was that the link between chaos and executive function would be moderated by socioeconomic risk. Specifically, we expected the strongest effect to be found for mothers in the most socioeconomically distressed households. If true, it would suggest that chaos had its strongest effects for the most vulnerable mothers—those with the fewest socioeconomic resources or most risks.

The data supported the second hypothesis. The statistical interaction between chaos and socioeconomic risk in the hierarchical regression equation was significant, accounting for 6% of the variance in maternal executive function above and beyond the statistical effects of the main effects of chaos and socioeconomic risk. This was not the case for maternal verbal ability (i.e., PPVT), suggesting a process that may be specific to executive function rather than to cognitive skills or intelligence more broadly.

Examination of the statistical interaction between chaos and socioeconomic risk (see Figure 2) showed a substantial shift in the magnitude of the association between chaos and executive function across the socioeconomic risk spectrum. The correlation was nonsignificant and modest for those with 3 or fewer socioeconomic risks, but significant and substantial (the equivalent of about two-thirds of the variance in executive function) for

mothers with four or five risk factors. The pattern strongly suggested a nonlinear threshold effect of socioeconomic risk at four risk factors, rather than a gradual linear effect. It is also worth noting that the statistical moderation effect of socioeconomic risk was significant even though the sub-sample of the highest risk households was small. Furthermore, descriptive analysis of risk factors (Figure 1) revealed that father unemployment was the variable that most clearly differentiated families with four risk factors from those with three or fewer risk factors. Father unemployment arguably is the most proximal indicator of family income level and stability of the five risk factors we measured. It may be that the statistical moderating effect of insufficient and unpredictable financial resources is particularly important, because it is under circumstances of income insecurity that the presence of household chaos may be most detrimental (Evans & Schamberg, 2009).

Overall, the moderating effect of socioeconomic risk on the link between household chaos and maternal cognitive self-regulation is consistent with bio-ecological and risk-resilience theories of individual functioning and household contexts (Bronfenbrenner & Ceci, 1994; Sameroff, 2010; Wright & Masten, 2005). The findings indicate that the deleterious effects of chronic household chaos on poorer cognitive regulation of attention and memory are not limited to children (Dumas et al., 2005; Evans & Schamberg, 2009) but may extend to mothers and perhaps fathers as well. Although we are not able to draw causal inferences from these cross-sectional correlational data, our interpretation is that the results represent a process of caregiver stress reactivity to the environment (Ackerman & Brown, 2010). Lower socioeconomic status mothers face more life stressors and household chaos compared to their more advantaged counterparts (Evans & Wachs, 2009). If the stressful circumstances are severe and chronic enough, it gives rise to physiological stress responses (e.g., elevated cortisol and heart rate) that affect brain regions critical to executive function, such as prefrontal cortex and hippocampus (Boyce & Ellis, 2005; Martorell & Bugental, 2006). Depletion of executive function skills under these stressful conditions may erode a mother's capacity for regulating her own thoughts, emotions and behaviors, as well as maintaining an ordered home life—effects such as those seen for mothers with ADHD symptoms (Mokrova et al., 2010). At the same time, the findings point to the resilience of some socioeconomically distressed mothers who have strong executive function skills and calm ordered households in spite of their families' stressful circumstances. There is much to be learned from such mothers regarding what they do to minimize chaos and maximize executive function.

Caveats and Conclusions

The current study was limited by its reliance on self-reported chaos. Although the questionnaire has been validated and is reliable, it does not capture the range of chaotic factors that matter in families' lives. Future research should use more rigorous assessment with interviews and direct observations of the physical environment of the home and neighborhood that would strengthen measurement, yielding data that may reveal different patterns of results. In addition, the self-reported inhibitory control scale had low reliability, which potentially reduced the construct and predictive validity of the executive function measurement construct. The study also was limited by the cross-sectional correlational design. Our emphasis has been on the hypothesis that chaos has deleterious effects on maternal executive function, but it is likely that maternal executive function also influences household chaos. Executive function has many connections to cognitive, emotional and behavioral self-regulation skills that are involved in planning and organization (Friedman et al., 2008)—skills and strategies that are necessary for maintaining a calm, ordered household.

With these caveats considered, the study has several implications for future research and for clinical intervention and prevention efforts that target enhancement of effective parenting.

The field needs basic and translational research that can make use of the knowledge that socioeconomic risk moderates the probable impact of chaos on mothers' cognitive self-regulation. One direction is for researchers to identify the processes that operate in less distressed families that appear to mitigate the link between chaos and maternal executive function. Another direction is to identify the processes in the most socioeconomically distressed families that bolster the resilient executive function and household management skills exhibited by some of the mothers in that context. Candidates include fewer stressful life events, living in a more advantaged neighborhood, maintaining better physical health and sleep, avoiding substances that impair cognitive functioning and physiological states, and having a more extensive and stable social support system (Nissan et al., 2005).

On the matter of cognitive and behavioral plasticity, individual differences in executive function become highly stable by young adulthood and also are substantially heritable (Friedman et al., 2008). However, this does not mean that the executive function skills of an individual cannot be modified. To the contrary, the current study points to potential plasticity in the connections between executive function and household regulation across the socioeconomic continuum, as do behavioral genetic studies showing large differences across the socioeconomic continuum in the heritability of cognitive functions (Turkheimer, Harden, D'Onofrio, & Gottesman, 2009). More direct evidence is found in experimental studies of children and adults that show plasticity in attention and memory components of executive function (Olesen, Westerberg, & Klingberg, 2004; Diamond et al., 2007; Thorell et al., 2008). For example, Olesen et al. found training effects for adults' working memory that were accompanied by increased prefrontal and parietal cortical activity. Similarly, Diamond et al. demonstrated with preschoolers that exposure to a training curriculum resulted in children's improvements in inhibitory control, working memory and cognitive flexibility.

Prevention programs for improving contexts to support effective parenting would do well to convey to parents, children, and other members of families' communities that it is important to maintain order, calmness, and daily routines whenever circumstances allow. This would pay dividends not only for children but for parents' own self-regulation, a personal resource that is critically important when stressors arise. Furthermore, parent education and intervention programs could be enhanced if cognitive and household regulation training and strategies were connected as part of a broader "home and family regulation" concept. This could build parental knowledge about the effects of stress and chaos on self-regulation, and about why stress reduction and self-regulation are so important to effective and enjoyable caregiving.

Acknowledgments

We are grateful to the participating families and our research staff and research assistants. Funding was provided by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development HD57319 and HD60110. We also received support from Virginia Tech's Institute for Society, Culture and Environment. Content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or NICHD.

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Figure 1.

Prevalence (% of sample) of five socioeconomic risks. This figure shows the percentage of sample that had each of five individual risk factors (single mother, father [f] low education, housing, mother [m] low education, father [f] unemployment), as a function of total number of risks.

Figure 2.

Correlations between executive function and chaos. This figure displays the correlations between maternal executive function and chaos as function of socioeconomic risk (black bars representing significant [$p < .05$] correlations).

Table 1

Descriptive Statistics and Bivariate Pearson Correlations (n = 136)

	Mean	SD	Correlations				
			1	2	3	4	5
1. Site (1 = urban, 2 = town)	1.31	0.46	---				
2. PPVT Age-Standard Score	102.56	14.64	.32***	---			
3. Socioeconomic Risks	1.26	1.48	-.26**	-.59***	---		
4. Chaos	2.26	0.66	-.02	-.22**	.25**	---	
5. Executive Function (z-score)	.04	0.97	-.06	.40***	-.40***	-.20*	---

* $p < .05$,

**

 $p < .01$,

 $p < .001$

Table 2

Standardized Coefficients from Hierarchical Regression Equation Predicting Maternal Executive Function (n = 136)

	Step 1 ^a	Step 2 ^b	Step 3 ^c
Site	-.21 ⁺	-.23 ^{**}	-.22 ^{**}
PPVT	.47 ^{***}	.31 ^{**}	.31 ^{**}
SES Risks		-.26 ^{**}	.23 [*]
Chaos		-.07	.02
SES × Chaos			-.26 ^{**}
-----	-----	-----	-----
ΔR^2	.20 ^{***}	.05 [*]	.06 ^{**}

⁺ $p < .10$,

^{*} $p < .05$,

^{**} $p < .01$,

^{***} $p < .001$

^a $\Delta F(2, 133) = 16.74, p < .001$;

^b $\Delta F(2, 131) = 4.55, p < .05$;

^c $\Delta F(1, 130) = 10.99, p < .001$