The Role of Basal Cortisol in Predicting Change in Mental Health Problems Across the Transition to Middle School

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ABSTRACT

Purpose: The period in which the transition to middle school occurs is marked by major changes in social context, social rules, and scholastic responsibilities. Some adolescents thrive during this period whereas others are overwhelmed and fail to cope adequately with their changing environment. We investigated basal cortisol upon waking as a predictor of change in mental health problems across the transition to middle school. By taking into account the transition experience, we extend prior findings that high basal cortisol predicts deteriorated mental health after the transition. In individuals with high awakening cortisol, we expected mental health problems to increase after negative transition experiences and to decrease after positive transition experiences, reflecting differential susceptibility. Evidence for the former but not the latter would suggest diathesis–stress.

Methods: Data from 1,664 subjects were obtained from two measurement waves (mean ages, 11 and 13.5 years) of the TRacking Adolescents’ Individual Lives Survey. Using linear regression, we investigated effects of awakening cortisol level, school transition experience, and their hypothesized interaction on change in mental health problems.

Results: We found that a negative but not a positive experience was predictive of change in mental health. Importantly, our results showed that a negative experience predicts deteriorated mental health only in adolescents with high awakening cortisol but not in adolescents with low awakening cortisol. This finding was robust across informants. The converse, high awakening cortisol predicting decreasing mental health problems after a positive transition was not found.

Conclusions: These results support the diathesis–stress model but not the differential susceptibility hypothesis.

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IMPLICATIONS AND CONTRIBUTION

We aimed to further our understanding of how basal cortisol, perception of an ecologically valid contextual variable, and psychopathology are associated. High awakening cortisol may mark vulnerability for deteriorated mental health after negatively perceived transitions. Stimulating positive transition experiences may aid in protecting vulnerable individuals, as in the diathesis–stress model.

Cortisol, the hormonal end product of the hypothalamic–pituitary–adrenal axis [1] is of interest as a potential biological correlate of internalizing and externalizing problems. Basal cortisol activity, representing cortisol levels in the absence of acute stress [2] has received relatively little attention, although recent evidence suggests that as much as 41%–57% of variance in basal cortisol is stable across days, and therefore accounted for by trait factors [3].

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Previous inconsistent and weak findings of a direct association between psychopathology and basal morning cortisol [2,4–7] may have resulted in part from unidentified interaction effects with environmental factors, given that basal cortisol has been associated with context sensitivity [8,9].

Theoretical models of environmental influences on mental health include diathesis-stress [10], differential susceptibility [11,12], and its predecessor, biological sensitivity to context [13,14]. According to the former, stressful contexts have negative impact on individuals with a certain vulnerability (diathesis) but less on individuals without that vulnerability.

Differential susceptibility refers to high context sensitivity not merely as disadvantageous in stressful contexts but also as advantageous in supportive, low-stress contexts. High context sensitivity is characterized by high attentiveness and responsiveness to environmental cues (e.g., social, emotional). Highly sensitive individuals can suffer from stress overload after sustained exposure to stress-related cues but can optimally benefit from the care and education they receive in supportive, low-stress environments [8]. In contrast, individuals with low context sensitivity are less attentive and responsive to their surroundings and will be less affected by stressful situations and positive experiences or efforts made by parents and teachers. Thus, differential susceptibility refers to context sensitivity for better and for worse, whereas diathesis-stress only covers the latter.

Individual differences in context sensitivity may be especially salient during periods of change. The period in which the transition to middle school occurs, usually between the ages of 11 and 13 years, is marked by major changes in social context, social rules, and scholastic responsibilities and challenges. Some adolescents thrive during this period whereas others fail to cope adequately with their changing environment. Shirtcliff and Essex [8] demonstrated that during the transition to middle school in particular children with high basal cortisol at the age of 11 years experienced a rise in problem severity whereas children with low basal cortisol did not develop these problems. The authors concluded that high susceptibility to contextual influences, as indexed by high basal cortisol, may be a risk factor for mental health problems in changing social contexts [8].

Although these results support the “for worse” aspect of differential susceptibility, the school transition is for many children likely to be positively challenging rather than stressful. Unfortunately, Shirtcliff and Essex [8] did not measure how children experienced the transition. Moreover, addressing both negative and positive environmental influences is key in testing for differential susceptibility because the “for better” aspect is what distinguishes susceptibility from vulnerability.

Therefore, in the present study, we extended prior research by taking into account adolescents’ perception of the transition to middle school. Distinguishing between positive and negative transition experiences enabled us to test more directly whether basal cortisol and environmental change interact in a way consistent with differential susceptibility. In a large sample of (pre)adolescents, we investigated basal cortisol upon waking as a predictor of change in mental health problems across the transition to middle school, a period of marked social change.

We expected to replicate prior findings that across the school transition high but not low basal cortisol predicts deteriorated mental health [8], but only in adolescents with a negative transition experience (1). Conversely, for adolescents with a positive experience, we expected high awakening cortisol to predict improved mental health and low awakening cortisol to predict stable mental health (2). Finding evidence for the first but not the second hypothesis would support diathesis-stress, whereas evidence for both would suggest differential susceptibility.

Methods

Sample

We derived the data used in this study from the longitudinal “TRACKing Adolescents’ Individual Lives Survey (TRAILS).” TRAILS aims to contribute to the understanding of the etiology of mental health problems by following 10- to 12-year-old Dutch children biennially into adulthood. TRAILS was approved by the National Dutch Medical Ethics Committee.

To obtain a large sample with wide ranges of problem severity and transition experiences, we pooled data from two TRAILS samples: a large population-based birth cohort and a smaller parallel clinic-referred cohort. We included two measurement waves, with mean ages approximately 11 (T1) and 13.5 years (T2). In the Netherlands, the school transition generally occurs within this time interval. Exceptions are children who skipped or repeated a year because they were ahead or behind school curriculum, respectively. Sampling procedures, descriptive statistics, response rates, and the possibility of selective attrition are well-documented for both cohorts [15–17]. In brief, TRAILS approached 135 primary schools in five municipalities in the Northern Netherlands to build the population cohort. Of these schools, 90.4% agreed to participate. TRAILScontacted eligible students and their parents, enrolling 76.0% (n = 2,230; mean age, 11.1 years; standard deviation [SD], 56; 49.2% boys). Of these T1 participants, 96.4% (n = 2,149) participated in T2 (mean age, 13.6 years; SD, .53). Data were collected from March 2001 to July 2002 (T1) and September 2003 to December 2004 (T2).

The clinic-referred sample (n = 543) consists of preadolescents who had been referred to the Groningen University Child and Adolescent Psychiatric Outpatient Clinic at any point in their life (20.8% ≤5 years, 66.1% 6–9 years, 13.1% 10–12 years) for consultation or treatment. Of the 1,264 eligible preadolescents, 43.0% (n = 543; mean age, 11.1 years, SD, .50; 65.9% boys) participated in T1. Of the 543 baseline participants, 85.1% (n = 462) participated in T2 (mean age, 12.9 years; SD, .62). Data waves ran from September 2004 to December 2005 (T1) and September 2006 to November 2007 (T2), 2 years behind those of the population cohort. Measurement instruments used in both cohorts were identical. Parents gave written informed consent before each assessment wave. Adolescents gave written informed assent at T2.

Measures

Mental health problems. TRAILS used the ASEBA family of measures of mental health problems [18,19]. The Youth Self-Report and Child Behavior Checklist contain 120 items assessing behavioral and emotional problems in children over the past 6 months. These items can be rated as 0 = not true, 1 = somewhat or sometimes true, or 2 = very or often true. Because findings by Shirtcliff and Essex [8] central to this study were not affected by symptom directionality, that is, internalizing or externalizing problems, we defined mental health problems as the sum of average scores on the DSM-oriented subscales anxiety, affective problems, oppositional deviant problems, and conduct problems. We computed T2–T1 change scores. Before analysis, we standardized the change score (M = 0, SD = 1) for ease of
interpretation because we were interested in deviations from the group mean.

Saliva collection. At T1, participants were instructed, verbally and in writing, to collect saliva at home on a regular school day without stressful or special events (e.g., a school test), without taking medication if possible, and in the absence of menstruation or feelings of illness. Saliva was collected on waking while still in bed, using the Salivette sampling device (Sarstedt, Nümbrecht, Germany). This device consists of a plastic sampling vessel with a suspended insert containing a sterile neutral cotton wool swab that has to be chewed for about 45 seconds and then returned to the insert [20]. The instruction stated that participants should rinse their mouth thoroughly with tap water and refrain from brushing their teeth and eating or drinking (other than water) until after the saliva collection was completed. Any deviations from the protocol (e.g., feelings of illness, special or stressful circumstances, delayed sampling) were reported on an accompanying form. Participants mailed the samples as soon as possible and kept them in the freezer before that. At the institute, samples were kept frozen (−20°C) until analysis [4]. Salivary cortisol (nmol/L) was measured by radioimmunoassay. A detailed description of the determination of cortisol levels is available elsewhere [20], as well as reasons for nonresponse in both cohorts [4,20]. Awakening cortisol level as an index of basal cortisol is, compared with other sampling times across the day, less likely influenced by confounding factors such as food or caffeine consumption and physical activity level, and the steep cortisol increase approximately 30 minutes after waking. We added a quadratic sampling month correction factor as a covariate [20].

School transition experience. At T2, adolescents indicated whether they had transitioned to middle school in the past 2 years. Additionally, participants were asked to indicate to what degree the transition was enjoyable and unpleasant using four-point scales (1 = not at all; 4 = very much). The measures were significantly correlated ($r = -.29, p < .001$). Pleasantness scores were reversed, then scores on the two items were summed, resulting in a distribution ranging from 2 = very enjoyable, not unpleasant to 8 = not enjoyable, very unpleasant. For ease of interpretation, scores were recoded into $-3 = $ very negative to $+3 =$ very positive.

Covariates. Covariates included age, sex (0 = female, 1 = male), the quadratic correction factor for cortisol sampling month [20], parent-assessed medication use, and physical maturation phase of the adolescents. Medication use was categorized into four dichotomous variables (0 = no; 1 = yes); corticosteroids, methylphenidate, other psychotropics (e.g., antidepressants, antipsychotics), and other somatic medication. Physical maturation at T1, when cortisol was sampled, was indexed by Tanner stage, ranging from 1 = infantile to 5 = complete puberty [21]. On a five-point scale, reflecting drawings of different stages, parents indicated their child’s developmental phase, with separate items for breast/genital development and pubic hair development.

Data analysis

Data preparation and preliminary analyses. Awakening cortisol levels were regarded as invalid in cases of noncompliance (i.e., >10 minutes after waking), unknown sampling time, or extreme values (more than three SDs from the mean). In case these participants did have a valid value on the second cortisol sample, collected 30 minutes after waking, we imputed awakening cortisol levels on the basis of the first assay’s group mean plus the participant’s standardized value of the second assay $\times$ the first assay’s SD, in line with previous studies [5,22,23].

Participants were excluded from this study if their school transition had not occurred in the past 2 years or if variables were missing, that is, we needed T1 awakening cortisol, T2 transition experience, and T1 and T2 self-reported and/or parent-reported mental health problems. We performed independent-samples $t$ tests to check whether included and excluded subjects differed with respect to our study variables and determine which medications were associated with awakening cortisol and would thus have to be included as covariates.

Main analyses. We computed Pearson’s correlation coefficients between the predictors and the change scores of self-reported and parent-reported mental health problems. Using PASW Statistics for Windows 18.0 (SPSS Inc., Chicago IL), we conducted separate linear regressions for change in self-reported and parent-reported mental health problems. All nondichotomous variables were centered before analysis. We used a multistep approach, with all covariates entered simultaneously in block 1, awakening cortisol level and transition experience in block 2, and cortisol $\times$ experience in block 3. We considered a $p$ value of <.05 to be statistically significant.

For interpretation of interaction effects, we plotted change in mental health problems on the basis of the estimated regression coefficients, for different levels of each predictor. Post hoc, we repeated our analyses without corticosteroids users; without covariates; separately for internalizing and externalizing problems; and checked for moderation by gender.

Results

Results of preliminary analyses

Mental health data were missing for 198 participants. Four hundred seventy-eight adolescents (96.2% population cohort) did not participate in the saliva (cortisol) collection. Cortisol measurement failed in 155 cases (e.g., not enough saliva to analyze or laboratory analysis failed), whereas cortisol values were invalid in 57 cases ($n = 20$ sampling delay > 10 minutes; $n = 12$ sampling time unknown; $n = 25$ extreme values). Cortisol values could be imputed in 111 cases ($n = 84$ missing; $n = 3$ noncompliance; $n = 24$ extreme values), resulting in a total of 2,194 valid cortisol values (79.9% population cohort) and 579 missing or invalid values (82.4% population cohort). In 431 cases, participants indicated that they had not transferred to middle school in the past 2 years; another 252 did not provide an answer. For 33 of the transferees, one or both of the experience items was missing.

Altogether, we excluded 1,109 participants (71.0% population cohort), resulting in a final sample size of 1,664 subjects (mean age, 11.2 years; SD, .54; range, 10.0–12.6; 51.4% boys; 86.7% population cohort).

Included subjects were younger ($t(2,769) = -4.412, p < .001$), had higher awakening cortisol level ($t(940.843) = 4.150, p < .001$), and fewer parent-reported mental health problems at T1 ($t(1,781.507) = -6.471, p < .001$) and T2 ($t(1,350.558) = -5.022$,
p < .001, than excluded subjects. The groups did not significantly differ with respect to sex (p = .15), pubertal stage (p = .41), transition experience (p = .93), and self-reported mental health problems (p = .86).

Although awakening cortisol was not significantly related to corticosteroids (n = 19; p = .98) or somatic medication (n = 39; p = .45), levels were significantly lower in methylphenidate users (n = 91; t(239.917) = -11.857, p < .001) and users of other psychotropics (n = 26; t(51.968) = -4.358, p < .001), compared to nonusers. Therefore, use of methylphenidate and other psychotropic medication were included as covariates.

**Descriptive statistics and correlations**

Table 1 shows descriptive statistics of our sample. Table 2 shows correlations between predictors and change in self-reported and parent-reported mental health problems.

**Basal cortisol and school transition experience**

As shown in Table 3, awakening cortisol level and transition experience significantly interacted in predicting change in mental health problems. For change in self-reported mental health problems, both the main effects and the interaction effect added significantly to the amount of predicted variance (R square change = .004, p = .025 in block 2 and R square change = .003, p = .016 in block 3). With regard to change in parent-reported mental health problems, the predictors did not add significantly to the amount of predicted variance (R square change = .002, p = .29), but the interaction did (R square change = .003, p = .026).

We plotted these interaction effects for low (-1 SD), average, and high (+1 SD) awakening cortisol level and for levels of school transition experience ranging from +3 = very positive to -2 = mostly negative. We did not depict -3 = very negative because it was rare (n = 10).

Figure 1 shows that a very positive experience of the school transition was associated with stable or somewhat decreasing levels of mental health problems across the school transition period. Conversely, a less positive experience was generally associated with an increase in mental health problems, especially in adolescents with high awakening cortisol level. However, as predicted, this typical increase in mental health problems in relation to a negative school transition was not observed in adolescents with low awakening cortisol level. Rather, levels of self-reported mental health problems in these adolescents with low awakening cortisol were stable across the school transition period, regardless of how the transition was experienced. Post hoc simple slopes calculation confirmed that mental health problems increased with less positive transition experiences for individuals with average (t(1629) = 2.725, p = .007) or high cortisol (t(1629) = 3.617, p < .001) but not for individuals with low cortisol (p = .84).

Parent-reported mental health problems largely showed the same pattern, that is, stable levels in adolescents who reported a

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Descriptive statistics of the variables used in this study</th>
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<tr>
<td>Cortisol</td>
<td>T1</td>
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<tr>
<td>EXP raw</td>
<td>T2</td>
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<table>
<thead>
<tr>
<th>Table 2</th>
<th>Correlation matrix of predictors and outcome variables</th>
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<td>∆MH</td>
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<td>EXP</td>
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<td>Cortisol</td>
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<tr>
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<td>Med1</td>
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<tr>
<td>Med2</td>
<td>.03</td>
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<tr>
<td>Puberty</td>
<td>.07***</td>
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</table>

ΔMH = Change in parent-reported mental health problems (T2–T1); ∆MH = change in self-reported mental health problems (T2–T1); Cortisol = awakening cortisol level; EXP = school transition experience; Month = quadratic correction factor for cortisol sampling month; Med1 = Methylphenidate; Med2 = other psychotropics; Puberty = Tanner stage of pubertal development. Sex was coded as 0 = female, 1 = male.

***Correlation is significant at the .001 level (two-tailed); **p < .01; *p < .05.
positive experience and increasing mental health problems after a less positive experience, especially in adolescents with high awakening cortisol level. Simple slopes calculation showed that mental health problems increased with less positive transition experiences for individuals with high cortisol ($t_{(1545)} = 2.295, p = .022$) but not for individuals with average ($p = .27$) or low cortisol ($p = .39$). Computation of regions of significance showed that the interaction effect between transition experience and awakening cortisol level was statistically significant below transition ratings of $−30$ for self-report and below $1.34$ for parent-reported mental health problems (corresponding to centered values of $−2.10$ and $−.45$, respectively). Conversely, the interaction effect was significant above transition ratings of $3.04$ for self-report and $8.22$ for parent-report, both exceeding the maximum value of this variable. We conclude that our findings apply especially to individuals who experienced the transition as ambivalent or negative.

Post hoc results show that our findings for self-report and parent-report were not altered by the exclusion of corticosteroids users ($p = .020$ and $p = .031$, respectively), nor driven by the correction for covariates ($p = .017$ and $p = .025$, respectively) or by problem direction (change in internalizing problems, $p = .025$ and $p = .013$, respectively, and externalizing problems, $p = .006$ and $p = .23$ (not significant), respectively). All outcomes yielded similar plots compared to Figure 1 which illustrates our main outcome.

Gender was a marginally significant moderator of our main results for self-report ($p = .06$) and parent-report ($p = .08$). Although a post hoc analysis, Figure 2 tentatively suggests that our main findings apply especially to girls.

### Discussion

This study investigated awakening cortisol level as a predictor of change in mental health problems across the transition to middle school, taking into account adolescents’ transition experience. We replicated the prior finding that adolescents with high basal cortisol were likely to show a rise in mental health problems across the transition to middle school whereas adolescents with low basal cortisol did not show an increase [8]. Moreover, this mainly applied to adolescents who reported a suboptimal (i.e., ambivalent or negative) transition experience, confirming our hypothesis. Regarding adolescents with an optimal (i.e., very positive) transition experience, we had expected decreasing levels of mental health problems in those with high cortisol, and stable levels in those with low cortisol. However, changes in mental health problems after an optimal experience were small and did not significantly differ by awakening cortisol level.

Whereas high awakening cortisol was a vulnerability factor for deteriorated mental health in an adverse context, we did not find support for context sensitivity for better and for worse. As such, our results support the diathesis-stress model [10]. Basal cortisol may, therefore, not be a marker of differential susceptibility or sensitivity to context as was proposed in the literature [8] but rather a marker of stress-sensitivity. Girls may be more sensitive to stress than boys because of earlier pubertal onset and different sex hormones that influence hypothalamic-pituitary-adrenal function.

Our findings should be interpreted in light of some limitations. First, cortisol assays were collected only once. Although recent evidence shows that single-day cortisol is informative with respect to trait influences [3], multi-day sampling of morning cortisol would have enabled us to more reliably assess stable trait influence [24]. Note that an underestimation of trait influence on awakening cortisol has likely resulted in an underestimation of effects, rather than an overestimation. Second, the school transition ratings were not derived from a previously validated measure. Third, shared method variance may have

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### Table 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$\Delta$ Self-reported problems</th>
<th>$\Delta$ Parent-reported problems</th>
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<td>Other psychotropics</td>
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<td>33.65</td>
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<td>Cortisol</td>
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<td>Experience</td>
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<td>Cortisol × experience</td>
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<td>4.32</td>
</tr>
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</table>

$\Delta =$ Change; Cortisol = awakening cortisol level. Sex was coded as 0 = female, 1 = male. All nondichotomous predictors were centered before analysis.

* Values multiplied by 1,000 for increased readability.

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### Figure 1

Change in self-reported (left panel) and parent-reported mental health problems (right panel) plotted for different levels of school transition experience and basal cortisol. $\Delta =$ Change ($T2 - T1$). Low $(-1SD)$, average, and high $(+1SD)$ awakening cortisol levels correspond to 6.23, 11.12, and 16.02 nmol/L, respectively. School transition experience levels represent $+3$ (++, very positive), $+2$ (+, mostly positive), $+1$ (+, somewhat more positive than negative), 0 (+/−, neutral), $−1$ (−, somewhat more negative than positive), and $−2$ (−−, mostly negative). The interaction effect is statistically significant on the right of the dashed line.
inflated associations with self-reported mental health problems because transition experiences were reported only by adolescents. However, shared method variance cannot explain interaction effects and results on parent-reported mental health led to the same conclusion. Finally, individuals excluded from analyses on the basis of missings had on average more parent-reported mental health problems than included individuals. Estimates may be somewhat conservative compared with when we would not have had this attrition.

Strengths of the study include the large sample of adolescents followed over the school transition period, large interindividual differences in mental health and transition experience, and multi-informant mental health data. Our results, that were consistent across informants, illustrate that associations between basal cortisol and psychopathology are more complex than often assumed, and help to understand why some individuals are more vulnerable than others to mental health problems in the context of environmental changes. Qualifying previous findings [8], we found that an ambivalent or negative but not a positive experience of the transition to middle school was predictive of change in mental health problems. These results imply that the perception of the transition rather than the transition itself affects mental health and that effects may pertain to experiences that yield psychological stress.

In addition, our results showed that a suboptimal transition experience predicts deteriorated mental health only in adolescents with high basal cortisol, not in adolescents with low basal cortisol. Taken together, high awakening cortisol level was a vulnerability factor for deteriorated mental health in adverse contexts but not a protective factor in beneficial contexts. Therefore, diathesis—stress rather than differential susceptibility best explains our data. Stimulating positive transition experiences, for example, by employing a buddy system, may aid in protecting vulnerable individuals.

Through replication and extension of previous findings, we have refined our understanding of the association between awakening basal cortisol, perceived experience of an ecologically valid contextual variable, and psychopathology. Our findings may extend to other major transitions. We recommend studies on long-term effects of other major life changes and how they are perceived, for example, school entry in preschoolers or labor market entry in young adults, in relation to mental health and awakening cortisol, analogous to studying mental health in relation to short-term cortisol reactivity to laboratory-induced stressors. Although the latter experimental design has been used widely, studies with real-life stressors and long-term effects have been few.

Acknowledgments

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