Age Differences in the Heritability of Mean and Intraindividual Variation of Psychological Distress

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Key Words
Negative affect - Behavioral genetics - Intraindividual variation - Emotion regulation

Abstract
Background: An important question in the study of intraindividual variability is whether the same explanatory mechanisms govern between-person variation and within-person variation. Objective: This paper investigates genetic and environmental influences on affect across varying time frames and genetic and environmental influences on within-person variation in affect. Methods: Twin participants aged 25–74 years provided information on their affective experiences over monthly, weekly, and daily recall periods. Questionnaires and daily telephone interviews were used to assess frequency of negative emotions. Results: Monthly, weekly, and daily reports of negative affect all showed modest genetic influences. Monthly and daily measures also demonstrated modest shared environmental influence. Sliding resemblance in within-person variation in effect was accounted for entirely by shared environment. Tests for age differences in magnitude of genetic and environmental effects revealed that genetic influences on monthly reports of affect were greater among older adults, but genetic influences on daily affective experiences were lower among older adults. Conclusions: Lowered heritability in daily affect among older adults contradicts standard behavior genetic expectations, and is consistent with the proposition that older adults gain skills in emotion regulation.

An important question in the study of intraindividual variability is whether the same explanatory mechanisms govern between-person variation and within-person variation. When this is the case the phenomenon is considered to have a property of epigenetic. For certain phenomena this property is unlikely [1]. For example, between-person differences reflected by mean levels of emotions may represent emotional set points and are likely to be influenced by genetically based dispositions whereas fluctuations around such set points (i.e., intraindividual variations) are more influenced by environmental conditions [2].

This paper uses a behavior genetic design to inform us about dispositional and environmental influences on negative affect within a life span framework. While substantial evidence suggests that negative mood is influenced by genetic factors [3, 4], few studies have investigated age differences in heritability. We investigate environmental and genetic influences on monthly, weekly, and daily

KARGER

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ISSN 0016-8845/2004/111-1996

Anzeigenservice: www.karger.com/ads

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report of negative affect. A focus on differing time frames allows us to compare more molar time references (i.e., monthly) that may reflect personality factors with more micro time referents (i.e., daily and weekly) that may reflect more situational and contextual influences on affect. The study also examined individual variability of daily affect. Using daily reports of negative mood, our diary design allows us to examine environmental and genetic sources of fluctuation in mood.

Our study was sparked by interest in the idea that people gain skills in emotional regulation as they age. Research suggests that older people report lower levels of negative affect [3], a finding that is sometimes interpreted as indirect evidence of developmental gains in the ability to regulate emotions [5, 6]. An alternative explanation, however, is that affect primarily reflects innate disposition and what is often interpreted as emotional regulation is in fact a genotype --> environment effect [7]. Scan's [7] work on intelligence, for example, shows increasing heritability for intelligence over time, which he interprets as evidence that people are selecting opportunities or contexts based on their interests and talents.

Genetic --> environment effects highlight potential correlations between person and their environments, such that people with more negative emotional dispositions experience more negative environments. This may reflect active gene-environment correlation, whereby people with greater temperamentally positive affectivity are more likely to choose social partners or contexts that maintain relatively positive emotions. Gene-environment correlation can also reflect more evasive effects. Some temperament styles may facilitate the development of positive relationships, whereas other styles may inhibit the development of relationships. For example, some people with depressive symptoms engage in excessive reassurance seeking, which leads to greater interpersonal rejection, which in turn can lead to greater depression [8]. Over time, therefore, we might see the environments covary with and amplify the effect of initial genetic differences, which people. If so, the cumulatiff effect of genetic differences in emotional experiences may lead to higher heritability estimates among older adults.

In contrast to the dispositional viewpoint, theories concerning age and emotional regulation suggest that older adults are better able generally to control their emotions. This explanation relies less on individual differences, which are potentially under genetic influence, than on general developmental gains. Labouvie-Vief and her colleagues have suggested that in adulthood, people reintegrate affective awareness into their cognitive understanding [9]. In support of her theory, adults were found to have significantly higher levels of emotional understanding and control when compared to adolescents. Other researchers also have found evidence of increased emotional regulation among older adults [5, 10]. Gross et al. [10] found that older adults across diverse cultural and social groups reported greater emotional control than younger adults, suggesting that this gain is a general developmental change. If people acquire generally the ability to control more effectively their emotions, this developmental gain is independent of personality. To the extent that personality is heritable, we would thus expect genetic effects to decrease over time. The purpose of this study is to examine age differences in heritability estimates as a way of investigating whether affect among older adults seems to be more reflective of innate temperament or whether there is evidence of developmental changes in the source of between-person and within-person variation.

Method

Sample and Procedure

Data for the analysis are from the National Study of Daily Experiences (NSDE), one of the in-depth studies that are part of the National Survey of Midlife in the United States Survey (MIDUS) carried out under the auspices of the John D. and Catherine T. MacArthur Foundation Research Network on Successful Midlife. The total MIDUS sample of 1,483 is comprised of 1,031 randomly selected respondents from the MIDUS random digit dialed (RDD) subsample and 452 MIDUS waves. We selected twins if twin pairs had high self-reported certainty of eligibility. For the present analysis, we used 219 same-sex twin pairs: 111 identical or monogemous (MZ) pairs, 99 fraternal or dizygotic (DZ) pairs.

Twins ranged in age from 25 to 74 years. Forty-seven percent of the respondents were male, 38% were female. The majority (76%) of respondents were married, 9% were divorced, 2% were separated, 2% were widowed, and 11% were never-married. Respondents were primarily white (92%). Six percent of the respondents were African American. Seventy-seven percent of the respondents were currently working, while 6% were retired.

Over the course of eight consecutive evenings, respondents completed short telephone interviews about their daily experiences. On the final evening of interviewing, respondents also answered several questions about their previous week. To aid independence of reporting, co-twins were interviewed at least two weeks apart. The initiation of interviews was staggered to allow for the possibility of confounding between day of study and day of week.

Negative affect

Our analyses make use of four measures of negative affect that differ in interval of recall and in level of aggregation. Each affect measure used an inventory of emotions from the Non-Specific Psychological Distress Scale [11]. The scale includes emotions such as sadness, hopelessness, anxiety, and restlessness. Respondents indicated how much of the time they experienced each emotion on a

Heredity of Variation in Distress

Cosenisology 2004;10:22-27

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Table 1. Age differences and sibling resemblance for negative affect variables

<table>
<thead>
<tr>
<th>Negative affect variable</th>
<th>Younger</th>
<th>MZ</th>
<th>Older</th>
<th>DZ</th>
<th>p&lt;0.05</th>
<th>p&lt;0.01</th>
<th>p&lt;0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly recall</td>
<td>0.16</td>
<td>0.15</td>
<td>0.14</td>
<td>0.13</td>
<td>-1.35*</td>
<td>0.18</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
<td>0.10</td>
<td>0.07</td>
<td>0.09</td>
<td>-1.77</td>
<td>0.22*</td>
<td>0.04</td>
</tr>
<tr>
<td>Daily recall</td>
<td>0.06</td>
<td>0.07</td>
<td>0.04</td>
<td>0.05</td>
<td>-4.06**</td>
<td>0.28**</td>
<td>0.13</td>
</tr>
<tr>
<td>Interaunal variation</td>
<td>0.07</td>
<td>0.06</td>
<td>0.05</td>
<td>0.03</td>
<td>-3.90**</td>
<td>0.21**</td>
<td>0.27**</td>
</tr>
</tbody>
</table>

* p<0.05; ** p<0.01; *** p<0.001.

Results

Analytical Analysis

Inspection of our variables revealed the presence of extreme values (z-scores >3). We used a log transformation to reduce the influence of outliers for all four variables. The daily affect scores for two individuals remained quite extreme (z-scores >3) after these transformations. We recoded these extreme values to missing.

Age and gender effects can serve to increase twin resemblance, which may be problematic when estimating genetic and environmental influences. Age was related significantly to all affect variables (t_logrec= -0.17, p < 0.001; t_dail = -0.14, p < 0.01; t_weekly = -0.14, p < 0.01), such that older adults tend to have lower levels of negative affect regardless of time frame. Older adults also reported less variability in daily affective ratings as compared to younger adults (t = -0.15, p < 0.01). Table 1 displays the age differences by providing the means and standard deviations for each of the affect variables for younger and older participants. The younger group (101 pairs) consisted of people whose ages ranged from 25 to 40. The older group (109 pairs) contained people age 41 and over. Respondents, on average, reported greater levels of negative affect when asked to recall over the entire week as compared to the aggregate of daily reports of negative affect across that same week. The discrepancy between the daily measure and the weekly measure suggested that respondents tended to overestimate the frequency of negative affect when they recalled their emotions over longer time intervals.

Significant gender effects were also present. Women reported higher levels of negative affect at the weekly (t = -2.11, p < 0.05) and daily (t = -2.39, p < 0.05) levels. Women also reported greater variability in daily affective ratings (t = -3.98, p < 0.001). Given these main effects, we controlled all four affect variables for both age and gender at the individual level. We then standardized each variable.

Sibling Correlations

In the first step of the behavior genetic analysis we computed the within-sibling correlations for each of the four variables (table 1). For the first three measures, the correlations for the identical twins were slightly to moderately higher than the correlations for the fraternal twins, indicating some genetic influence for the mean level of negative affect. For intraclass variability in affect, however, the correlation for fraternal twins was actually higher than that among identical twins. This pattern suggests twin resemblance for variability in affect can be attributed to shared environment and that genetic factors do not explain individual differences in intraclass variability.

Structural Equation Modeling

To obtain estimates of genetic and environmental influences on negative affect, we conducted a series of...
Table 2. Model fitting results

<table>
<thead>
<tr>
<th>Negative effect variable</th>
<th>χ²</th>
<th>df</th>
<th>p</th>
<th>RMSEA</th>
<th>AIC</th>
<th>Proportion of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.68</td>
<td>0.88</td>
<td>3</td>
<td>0.000</td>
<td>5.32</td>
<td>0.09 0.10 0.82</td>
</tr>
<tr>
<td>Weekly</td>
<td>1.11</td>
<td>0.77</td>
<td>3</td>
<td>0.000</td>
<td>4.89</td>
<td>0.20 0.00 0.80</td>
</tr>
<tr>
<td>Daily</td>
<td>2.60</td>
<td>0.46</td>
<td>3</td>
<td>0.018</td>
<td>3.40</td>
<td>0.14 0.15 0.71</td>
</tr>
<tr>
<td>Intrindividual variance</td>
<td>4.52</td>
<td>0.21</td>
<td>3</td>
<td>0.053</td>
<td>1.18</td>
<td>0.00 0.24 1.76</td>
</tr>
</tbody>
</table>

Table 3. Model fitting results for age difference model in daily negative affect

<table>
<thead>
<tr>
<th>Negative effect</th>
<th>χ²</th>
<th>df</th>
<th>p</th>
<th>RMSEA</th>
<th>AIC</th>
<th>Proportion of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Younger people</td>
<td>6.84</td>
<td>6</td>
<td>0.25</td>
<td>0.085</td>
<td>4.16</td>
<td>0.00 0.24 0.76</td>
</tr>
<tr>
<td>Older people</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily</td>
<td>6.68</td>
<td>6</td>
<td>0.33</td>
<td>0.037</td>
<td>5.32</td>
<td>0.20 0.23 0.57</td>
</tr>
<tr>
<td>Younger people</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Older people</td>
<td>0.00</td>
<td>0.09</td>
<td>0.91</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Structural Equations Models via the Mx program [12]. This procedure allowed us to decompose the observed variance in each of the variables into three factors: Additive genetic influences (a), shared environmental influences (c), and non-shared environmental influences (e). Genetic influences accounted for between 9 and 20% of the variance in mean levels of negative affect. Shared environmental influences accounted for minimal variance in the mean levels weekly negative affect, but had a modest effect on both monthly and daily affect. The largest share of variance in all models was attributable to unique (non-shared) environmental influences. The last row in table 2 shows the results for intrindividual variation. Shared environmental influences accounted for 24% of the variance in daily mood, whereas genetic influences were minimal. Again, non-shared environment accounted for a substantial portion of the variance (74%).

Age Differences
The final set of analyses assessed age differences in the magnitudes of genetic and environmental influences in the previous models. We compared models that constrained parameters to be equal across the age groups with models that allowed parameters for younger twin pairs to differ from older pairs. This allowed us to see whether observed phenotypic variance within each group can be differentially apportioned.

A model in which parameters differed across the two age groups fit better than one in which genetic and environmental estimates were constrained to be equal for both monthly and daily levels of negative affect. Model fitting results and parameter estimates for the age difference models are provided in table 3. For monthly levels of negative affect, the pattern follows the standard behavioral genetic prediction: genetic influences are larger among older adults as compared to younger adults. In addition, shared environmental influences are stronger among younger adults. A different pattern emerges for daily levels of negative affect; however, heritability is larger among younger adults than among older adults, as in shared environment.

Discussion
The results of these analyses suggest three findings. First, regardless of time frame, mean level of negative affect is partially heritable. This finding is consistent with prior studies noting significant heritability for depression [13] and negative affect [3]. Our results provide evidence that genetic influences can account for individual differences in general affective tendencies and in day-to-day negative mood. Second, evidence for shared environment was found for monthly and daily levels of negative mood.
as well as variation in daily mood. Shared environment among these adult twins may be reflective of daily events or stresses that revolve around the family. In addition, the role of shared environment in negative affect may reflect parental socialization concerning emotion. Eisen- berger, Sutherland, and Spindel [14] note that emotional socialization may focus particularly on negative emo-
tions. Third, for both age groups, there was no evidence for genetic influences on intradividual variation. Shared environmental influences, however, were sizeable. This finding supports the set point theory [2]: baseline or average mood is heritable, while fluctuations around that set point are primarily due to environmental events.

Age differences in genetic and environmental effects were present for monthly and daily affect. Genetic in-
fluences explained more of the variance in older adults' monthly affect, and shared environmental influences ex-
plained less, as compared to younger adults. This pattern followed the dispositional viewpoint, with genetic effects amplified over time. Daily affect, however, revealed a dif-
ferent pattern of results. Shared environmental estimates were again higher among younger adults. This finding is not surprising, reflecting greater temporal proximity to the shared rearing environment. The absence of genetic influence on affect among older adults, however, fails to confirm the dispositional viewpoint. Overall, the pattern supports the idea that temperament is no longer as strong a predictor of differences in day-to-day negative affect among older adults. While the cross-sectional nature of the study does not allow us to interpret this as an age change, the finding is consistent with the concept of develop-
mental gains in emotional regulation.

How can we reconcile the disparate patterns for daily and monthly affect? We suggest that this difference arises, in part, because monthly and daily measures of affect assess different aspects of affective experience. Prior re-
search has shown that people tend to overestimate the intensity of emotions over longer time frames [15, 16] and tend to rely on most recent (end) and peak affective expe-
riences when recalling retrospectively [17, 18]. Our re-
spondents demonstrated a similar pattern, recalling greater-
ner frequency of negative affect over the past week than indicated by their actual daily experiences. Perhaps some of the genetic effect on affect is unique to the experience of particularly intense or frequent negative emotions, which serve to bias people's recall. It should be noted that while we can test whether sources of variance differ between age groups, we cannot explain mean-level differences between groups using our basic behavior genetic model. Nevertheless, significant age differences in the proportion of variance attributed to genetic and environmental influences provide a unique perspective on developmental changes. Our findings high-
light two divergent patterns, with differing implications.

In the case of monthly affect, heritability was greater among older adults. The next step is to understand how this difference develops. Is it an age-related change? What environments or experiences can account for an amplifi-
cation of genetic effects over time? In the case of daily affect, heritability was lower among older adults. De-
creased heritability over time calls for its own unique developmental explanation. We suggest that this pattern is consistent with the idea that people gain emotional reg-
ulation skills over time, but this connection should be explored explicitly in future research. Younger adults had higher levels of daily affect, and a greater portion of the differences among younger adults in daily affect was attributable to genetic effects. Overall, our findings sug-
gest that temperament plays less of a role in explaining between-person differences in day-to-day affect as we age. A decline in the role of temperament can be explained by a general developmental gain in emotional regulation that is independent of personality or innate factors.

Acknowledgment

This project was supported by the John D. and Catherine T. MacArthur Foundation Research Network on Successful Midlife Development, the W.K. Kellogg Foundation, the Alfred P. Sloan Foundation and grants from the National Institute of Mental Health (MH33532) and the National Institute on Aging (AG016731).

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Nevis/Aldritha

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