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Heritability of Self-Esteem from Adolescence to Young Adulthood

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The heritability of self-esteem was investigated in a sample of 289 monozygotic (MZ) and 452 dizygotic (DZ) twin pairs from the National Longitudinal Study of Adolescent Health (Add Health). Self-esteem was defined by four items from the Self-Esteem Scale (Rosenberg, 1965). Age of the sample ranged from 10-20 years at baseline; follow-up data were collected at baseline and approximately 1.5 and 7 years later. Self-esteem measured during adolescence at 14.9 years average age and 16.5 years average age was more heritable (42.5% and 45%, respectively) than self-esteem in young adulthood, 21.8 years average age (13%). However, the common component of self-esteem that is stable across all three time points was much more heritable (75%) than that for any single time point examined separately. The implications for genetic and environmental influences on self-esteem development are discussed.

Self-esteem is one of the most well researched constructs in psychological science. Several behavioral, psychological and physical health outcomes have been linked to self-esteem including substance use (Brehm & Back, 1968; Walitzer & Sher, 1996), externalizing problem behaviors and aggression (Barnow, Schuckit, Lucht, John, & Freyberger, 2002; Donnellan, Trzesniewski, Robins, Moffitt, & Caspi, 2005; Fergusson & Horwood, 2002; Rosenberg, Schooler, & Schoenbach, 1989), psychiatric disorders (Silverstone & Salsali, 2003), suicidality (Brent, et al., 1986; Dukes & Lorch, 1989; Kienhorst, de Wilde, Van den Bout, Diekstra, & Wolters, 1990; Overholser, Adams, Lehnert, & Brinkman, 1995; Robbins & Alessi, 1985), and even mortality (Stamatakis, et al., 2004). However, the etiology of self-esteem, whether biological or environmental, and the contributory role of self-esteem in psychological and behavioral health has not been firmly established (Baumeister, Roy F., Campbell, Krueger, & Vohs, 2003).

A large majority of the current body of research examining the etiology of self-esteem has focused mainly on socio-environmental determinants. Several environmental measures have been associated with low self-esteem including lower social support (Greene & Way, 2005; Harter, 1990; Hirsch & Dubois, 1991; Leary, M. R. & Downs, 1995), low socioeconomic status (Twenge & Campbell, 2002), negative parenting (Gecas & Schwalbe, 1986; Kernis, Brown, & Brody, 2000), maltreatment (Kaplan, Pelcovitz, & Labruna, 1999) and stressful life events (Baldwin & Hoffman, 2002; Masten, et al., 1999). Measuring environment alone, however, may not fully explain self-esteem development. Observations of adolescents who have been exposed to environmental and psychosocial risk factors who do not always exhibit the expected negative outcomes (Garmezy, 1991, 1993; Masten, 1994; Rutter, 1985; Werner, 1993) have suggested the existence of protective factors specific to the individual.

Behavioral genetic research has begun to make breakthroughs in describing the influence of genes on personality, but the potential influence of genes on self-esteem has received relatively little attention despite the growing evidence suggesting that self-esteem is heritable (Neiss, Rowe, & Rodgers, 2002). Self-esteem has been conceptualized as a trait-like construct that is moderately stable over time (Rosenberg, 1986) and is indicative of one's level of self-liking that colors self-competence or specific appraisals of the self (Baumeister, R. F., Dori, & Hastings, 1998; Holye, Kernis, Leary, & Baldwin, 1999; Leary, M. R. & Downs, 1995; Rogers, 1961). High self-esteem is interpreted as a genuine and stable liking for oneself, while low self-esteem is

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interpreted as ambivalent feelings and possibly negative feelings towards oneself (Baumeister, R. F., Tice, & Hutton, 1989). Few behavioral genetic studies of self-esteem exist. In one of the first twin studies assessing the heritability of self-esteem, Roy, Neale, and Kendler (1995) interviewed 17-50 year-old Caucasian females (430 monozygotic and 308 dizygotic pairs) and found greater similarity between monozygotic (MZ) twins (rtime1 = 0.40; rtime2 = 0.36) than dizygotic (DZ) twins (rtime1 = 0.21; rtime2 = 0.12). The heritability of self-esteem was estimated to be 40% at the first time point and 36% 16 months later, while shared environment appeared to have very little influence. Furthermore, when predicting change in self-esteem over time the genetic contribution was even stronger (56%). Examining the stability in self-esteem over time, in addition to level at any one time point, provided evidence that genes influence self-esteem development, at least in females.

A later study examined a larger sample of 3793 twin pairs, both males and females, with an average age of 35 years old, from the Virginia Twin Registry (Kendler, Gardner, & Prescott, 1998). Similar to previous heritability estimates for self-esteem, this study found that MZ twins (rmales = .30; rfemales = .35) showed more similarity than same sex DZ twins (rmales = .11; rfemales = .16). Approximately 29% and 32% of heritability in self-esteem, for males and females respectively, could be attributable to genetic factors (Kendler, Gardner, & Prescott, 1998). Similar to Roy et al. (1995), the best model fit did not include shared environment while unique or non-shared environment had a significant contribution to self-esteem scores (e2males = .72 and e2females = .66).

In a much smaller sample of 50 MZ and 31 same sex DZ Japanese adolescent and young adult sibling pairs, the interclass self-esteem correlations for MZ twins was r = .48 and r = .08 in same-sex DZ twins(Kamakura, Jukoando, & Ono, 2001). The best-fitting model in this sample, as with the previous two studies, included only genetic (a2 = 49%) and non-shared environmental effects (e2 = 51%).

Similar findings have been shown in studies that have included sibling samples with greater diversity in their genetic and environmental background than the study samples previously mentioned. McGuire, Neiderhiser, Reiss, Hetherington, and Plomin (1994) examined 720 siblings from the Nonshared Environment and Adolescent Development (NEAD) Project, which included twins and full-siblings from non-divorced and divorced families, and from full-sibling, half-sibling, and unrelated sibling pairs. Their analysis employed various types of sibling relationships with varying levels of shared environmental backgrounds and showed a 29% heritability estimate for self-esteem. McGuire et al. (1999) reported follow-up data of this sample three years later using a smaller subset of the original sample. This study not only showed a greater heritability of self-esteem at time 2 (a2 = 0.66) but also that continuity in self-esteem was largely attributable to genetic factors. Stability of self-esteem scores between time 1 (mean age = 13.6) and time 2 (mean age = 16.2) was more similar between MZ twins (r = 0.41) than for DZ twins (r = 0.16), suggesting that self-esteem stability is heritable. The longitudinal information suggests that there may be a difference in univariate assessments compared to the evaluation of stability of genetic and environmental sources of individual variability. Consistent with a trait definition of self-esteem, in addition to a significant heritable component, self-esteem is relatively stable over the life course. A recent meta analysis of 50 studies supported the stability of self-esteem over the life course; the test-retest correlation of self-esteem was 0.47 across all age groups and did not seem to differ by gender or ethnicity (Trzesniewski, Donnellan, & Robins, 2003), thus substantiating self-esteem as a trait.

Yet, due to the impact of normative socio-contextual factors, including typical challenges and milestones of development, self-esteem level still exhibits moderate fluctuations across the life course. In particular, a major change in self-esteem occurs during the early adolescent or the "storm and stress" period, as described by Erikson (1968). The "storm and stress" period experienced during adolescence makes these developmental years important for the study of resiliency and health outcomes. Identifying those who have a greater decline in self-esteem during this period may provide data and direction for early intervention with at-risk groups. From childhood (7-8yrs old) to early adolescence (13- and 14-yrs old), there is a decline in self-esteem; this decline is greater for females of all ethnic groups and nationalities (Trzesniewski, Robins, Roberts, & Caspi, 2004). A large cross-sectional study found that self-esteem declined sharply from childhood (ages 9–12) to adolescence (ages 13-17) and continued to decline into college age, 18 to 22 years old (Robins, Trzesniewski, Tracy, Gosling, & Potter, 2002). Despite these general trends in the population, individual differences may determine stability of self-esteem and psychosocial health outcomes through the "storm and stress" period of adolescence.

Self-esteem has also been shown to fluctuate day-to-day. As such, some have argued that self-esteem is strongly contextually driven and should be considered at the state level (Kernis, 2005; Leary, M. R. & Baumeister, 2000). In fact, large day-to-day fluctuations in self-esteem, or low self-esteem stability, have been associated with poorer psychological functioning including hostility proneness, excuse making, and poor reactions to interpersonal feedback (Kernis & Waschull, 1995). A major limitation of self-esteem stability, however, is that it is difficult to measure. Due to logistic constraints, population based samples typically do not include a measurement of self-esteem lability. Instead of considering day-to-day changes in self-esteem over a week or 30 days, this project will examine self-esteem change among adolescents in grades seven through 12 who were followed for approximately seven years (i.e. Add Health). The Add Health data set will allow for examinations of self-esteem level at one and a half and six year intervals. Changes in self-esteem across these larger time periods may indicate responses to significant transitions or life events.

Using previous research as a guide, the current study had four specific aims. First, previous studies showed that genetic contribution, but not shared environment, contributes to the correlation of self-esteem scores between siblings. Thus, the first aim was to determine whether an estimate of genetic and/or shared environment needed to be included in a model comparing twins' self-esteem. If the model best fitting the data does not include an estimate of genetic contribution, this would suggest that self-esteem is not heritable. Previous studies, however, found that not only is self-esteem heritable but self-esteem stability showed an even larger heritability estimate than self-esteem measured at a single given point in time. Therefore, the second aim of this study was to examine self-esteem measured across three time points to determine the heritability of the self-esteem component that is stable from adolescence through young adulthood. The third aim was to follow up this analysis by estimating the heritability of self-esteem at each single time point. Evidence from previous studies would suggest that the heritability estimate at any single measurement alone would be smaller than the heritability estimate for self-esteem stability. If this is true, then it will be important to evaluate whether the genetic factor(s) influencing self-esteem are stable over time. Thus, the fourth and final aim of the study was to evaluate whether the genetic factors affecting self-esteem in adolescence and adulthood are correlated. A high correlation may suggest a very stable genetic influence over time (i.e. the same genetic factors influence self-esteem both during adolescence and young adulthood), whereas, a low correlation may suggest changing genetic contributions over time.

Methods

This study examined a sub-sample of the National Longitudinal Study of Adolescent Health (Add Health), a longitudinal study of a nationally representative sample to examine adolescent health, health-related behaviors, and the causes and consequences of these behaviors. This sample was followed from middle school and high school—grades 7 through 12—through early adulthood (Harris, et al., 2003). The siblings sample includes full sibling pairs (n = 1,249), half sibling pairs (n = 424) and biologically unrelated sibling pairs (n = 657). Adolescents could qualify for more than one sample in the Add Health data set. Sex and race of the subjects was determined by self-report. All subjects were categorized into five broad racial groups: white, black, non-white Hispanic or Latino, Asian/Pacific Islander, or American Indian/Native American. For accuracy, age was determined by subtracting the date of interview from the subject's reported birth date. From the total sibling sample, a sample of MZ and same sex DZ twin pairs was created for the current analyses. To determine possible errors in zygosity, seven candidate polymorphisms in the following genes were compared among the MZ twin pairs: DAT1 (dopamine transporter), DRD4 (dopamine receptor), SLC6A4 (serotonin transporter), MAOA-u (monoamine oxidase A-uVNTR), MAOB (monoamine oxidase B), DRD2 (dopamine D2 receptor), and CYP2A6 (cytochromeP450 2A6). Two MZ pairs were deleted due to incongruent genotypes, which may indicate error in the determination of zygosity or error in genotyping. This resulted in a sample of 289 MZ twin pairs and 452 DZ twin pairs. Females composed 53% of the sample. Racial break down and age of this group was very similar to that of the total sample; 60% (n=448) of the pairs were white, 17% (n=127) were black, 16% (n=118) were Latino or Hispanic. Average age of the twin pairs at Waves I, II, and III was 14.9 (SD = 1.6), 16.5 (SD = 1.7), and 21.8 (SD =1.7), respectively. There were no sex or race differences in age.

Measures

Self-esteem. Self-esteem was measured using four revised items from the Rosenberg Self-esteem Scale (RSES; Rosenberg, 1965) based on a five-point likert-scale, all positively coded. This measure was given to participants at all three waves. Confirmatory factor analysis (CFA) was conducted to determine whether these items measured the same construct and would adequately represent self-esteem for both MZ and DZ twins. Using wave I data of the total sample, CFA indicated that these four items loaded significantly (all >.60) on one factor. All four self-esteem items are: "You have a lot of good qualities", "You have a lot to be proud of", "You like yourself just the way you are", "You feel like you are doing everything just about right." In a measurement model testing the latent self-esteem construct at all three time points, all loadings were constrained to equal across time without a significant decrease in fit. The error terms were correlated in the measurement model to represent the hypothesis that the unique variances of the four self-esteem items overlap. The final measurement model showed adequate fit 2 = 410.42, df = 49, CFI = .93, RMSEA = .078 (.072 - .086). In univariate analyses, self-esteem was measured by calculating the average scores across the four items for each subject.

Analyses

It is assumed in the basic quantitative genetic model that differences among people on a trait of interest, or phenotype, can be attributed to three sources of variation: (1) additive genetic variance (V_A), (2) variance due to common experiences shared by family members living together (V_C)(e.g., parental socioeconomic status), and (3) variance due to unique experiences specific to the individual and not shared by the family members (V_E)(e.g., work history in adulthood). More explicitly, the phenotypic variance (V_P) can be expressed as:

$$V_P = V_A + V_C + V_E$$

If each term in the above equation is divided by VP, such that the phenotypic variance now equals unity, the following expression results:

$$1 = a^2 + c^2 + e^2$$

Where a^2 is heritability, or the proportion of the phenotypic variance attributable to additive genetic variance, c^2 is the proportion of variance attributable to shared environmental influences, and e^2 is the proportion of variance attributable to non-shared environmental influences.

Although the components of variance are unobserved or latent variables in quantitative genetic analyses, they nonetheless can be estimated from monozygotic (MZ) and dizygotic (DZ) twin correlations and variances. The correlation between genotypes in MZ twin pairs is 1.0, since they are genetically identical, while the correlation between genotypic values in DZ twins is 0.5, since they share, on average, half of the segregating alleles. By definition, both MZ and DZ pairs are assumed to be influenced by their shared environments to the same extent, thus the correlation between S_1 and S_2 is constrained to equal 1.0. Although MZ twins may have been treated more alike than DZ twins, the model assumes that, on average, this differential treatment will not significantly affect estimates of shared environmental influences (Loehlin & Nichols, 1976). The expected correlation between Twin 1 and Twin 2 on a single phenotype is then a function of the genes and environment that they share, and can be derived by aid of the path diagram. So, the expected correlations are $a^2 + c^2$ for MZ twin pairs and $1/2a^2 + c^2$ for DZ twin pairs.

Comparisons of the full model to reduced models, which have elements of the full model constrained to equal zero, are reported and represented as a χ^2 ($\chi^2_{Reduced}$- χ^2_{Full}= $\chi^{2\Delta}$, whose degree of freedom is calculated as; $df_{Reduced}$-df_{Full}=df)(For a review of these procedures see Neale, Cardon, & North Atlantic Treaty Organization. Scientific Affairs Division, 1992). To test for the significance of each reported heritability estimate, the ACE form of each model was compared to a CE model that did not include an estimate of genetic heritability. A non-significant chi-square would indicate that the heritability estimate can be dropped without a decrement in model fit, and therefore, the genetic contribution to the trait is non-significant. In contrast, a significant chi-square would suggest that an estimate of heritability must be included in the model and suggests that the genetic contribution to the trait is significant. Models were fit using Lisrel VII statistical modeling package (Jöreskog & Sörbom, 1996). Prior to performing the modeling we calculated the phenotypic correlation between twins on self-esteem. The interclass correlations were calculated separately for MZ and DZ twins.

The component of self-esteem that is stable at three time points was examined using repeated measures. Figure 1 shows the SEM model for self-esteem as a latent (or stable) construct, and the latent factors A, C, and E, which influence this construct. The latent construct self-esteem is composed of shared variance among the three self-esteem measurements. Therefore, it represents the portion of self-esteem that does not vary or is stable from adolescence to adulthood and is free of measurement error. At the bottom of the figure, the latent self-esteem construct then influences the observed variables through paths lambda, while paths k reflect measurement error or short-term fluctuations in self-esteem (i.e. unique variance at each measurement).

Figure 1. Multivariate model of self-esteem.

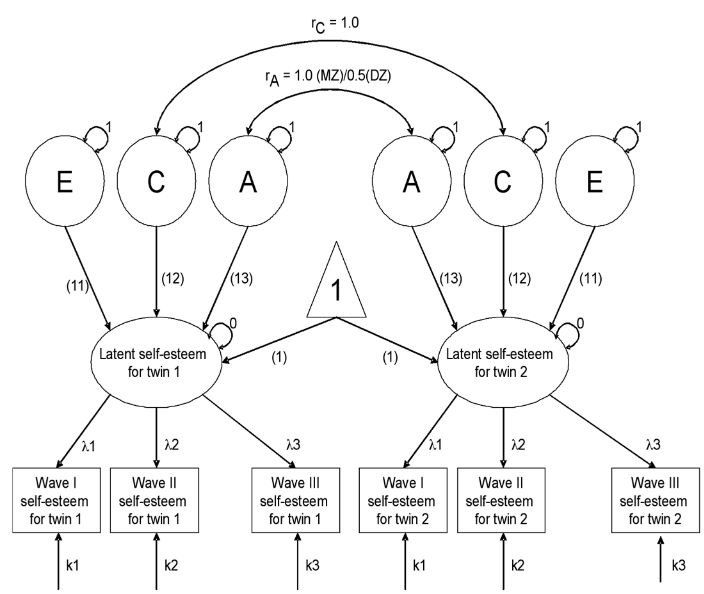
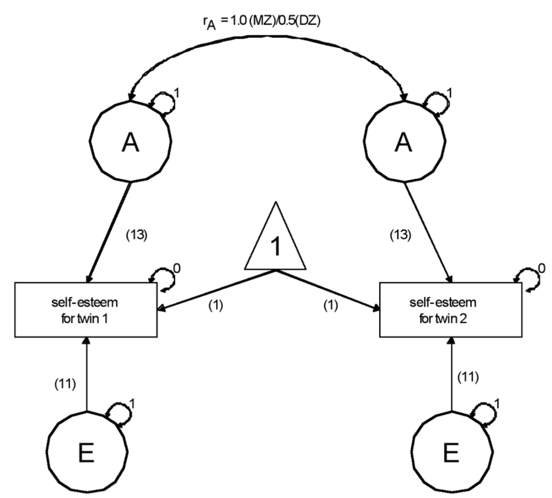


Figure 2. Univariate model of self-esteem.



Results

Multivariate Model

To determine whether genetic and/or shared environment had a significant influence on self-esteem, an ACE model was compared to AE and CE models in the full data set. Only the best fitting model would be retained for subsequent analyses. First, the full ACE model depicted in Figure 1 was tested and then the alternative models were tested against this one using Chi Square difference tests. The full ACE model, including self-esteem measurement at all three time points demonstrated excellent fit (χ^2 = 27.57, df = 30, CFI = 1.00). The A, C, and E estimates were .72, .05, and .23, respectively (Table 1). Next, an AE model postulating that all familial aggregation results from additive genetic effects was tested against the full ACE model. A non-significant chi square difference test suggested that a model of genetic transmission (AE model) explained the data as well as a model of mixed genetic and environmental transmission (ACE). However, when testing a model that included environmental transmission only (CE; χ^2 = 39.70, df = 31, CFI = .98), a one-degree of freedom test showed a significant decrement in fit when A was not estimated. This suggests that genetic transmission must be considered in self-esteem models, while shared environment was less important. In light of this finding, the shared environmental component was excluded from all subsequent models while A, the estimate of genetic transmission, was retained. Next, the more parsimonious AE model was tested to determine the heritability estimate of the latent self-esteem construct composed of all three self-esteem measurements. The model fit and estimates for this model are shown in Table 1. According to this model, the stable component of self-esteem was estimated as 77% heritable, with unique environment accounting for the remaining 23%.

Univariate Self-Esteem Models

Univariate models estimating the heritability of self-esteem cross-sectionally at each time point followed the multivariate model. The AE model that was fit for each measurement is shown in Figure 2. Goodness-of-fit statistics, additive genetic, and unique environmental contribution estimates at all three time points are reported in Table 2.

Table 2 shows that the heritability estimates of self-esteem for Waves I, II, and III were 42%, 45%, and 13%, respectively. The considerably lower values in the repeated measures model may suggest large error in the single point measurement of self-esteem. Furthermore, a large increase in parameter e^2 at Wave III may indicate significant changes in self-esteem from adolescence to adulthood that are primarily due to environmental influences not shared between twins. A test of the heritability estimate, which compares the ACE model to the CE model, was non-significant at Wave III ($p > .05$), suggesting that self-esteem is not explainable by genetic influence in early adulthood.

To ensure the validity of the values shown in Table 2, identical models were run in random halves of the sample. Parameter estimates and inter-twin correlations in both half samples did not differ from those reported in Table 2, suggesting that the decrease in a^2 at Wave III is not due to random error as the same results were produced from two independent analyses.

The current sample includes both same-sex and opposite-sex DZ twin pairs. Although some studies have

Table 1
Fit Statistics and Estimates for Multivariate Twin Models

	Parameters			Fit of the model		
	a2	c2	e2	χ2	df	CFI
Full ACE Model	0.717	0.047	0.235	27.313	30	1.000
Full AE Model	0.773	0.228	27.646 31	1.000		

Table 2
Descriptives, Fit Statistics, and Estimates for Univariate Twin Models

	Twin 1 - Twin 2 Correlations			Parameters		Fit of the model		
	Age	MZ	DZ	a2	e2	χ2	df	CFI
Time1 (n=740)	15	0.456	0.179	0.425	0.575	8.099	7	0.986
Time2 (n=690)	16.5	0.481	0.210	0.450	0.549	7.542	7	0.993
Time3 (n=600)	22	0.108	0.091	0.130	0.870	1.115	7	1.000

suggested there are no differences in concordance between same-sex and opposite-sex twins, it is generally accepted that concordance rates are two to three times greater among same-sex DZ twins than opposite-sex DZ twins (Joseph, 2004). As such, typical twin methods makes comparisons between identical and same-sex DZ twins. To confirm that the current findings were not due to decreased concordance among opposite-sex twins, the twin models described above were run using MZ and same-sex DZ twins only—opposite-sex twins were excluded from the analyses. This resulted in samples at Waves I, II, and III that were n=527, 478, and 373, respectively. These analyses yielded similar parameter estimates to those reported in the larger sample. In the smaller samples, the heritability estimates of self-esteem for Waves I, II, and III were 45%, 48%, and 14%, respectively. Again, heritability of self-esteem was not significant at Wave III. In the multivariate model, the available sample of MZ and same-sex DZ twins was n = 372. According to this model, the stable component of self-esteem was estimated as 80% heritable, similar to that reported in the larger sample. Overall, the reported heritability estimates were consistent even in smaller samples.

Bivariate Self-Esteem Models

To further test the heritability of self-esteem and evaluate whether the genetic factors affecting self-esteem in adolescence and adulthood were correlated, two bivariate twin models comparing Wave I to Wave III and Wave II to Wave III self-esteem measurements were analyzed. Figure 3 shows the model comparing measurements at these two time points.

This analysis partitions phenotypic association between time 1 and time 2 measurements into genetic and environmental sources of covariance. As displayed in Figure 3, parameters a_{11} and e_{11} reflect additive genetic and non-shared environmental components unique to time 1, a_{21} and e_{21} reflect these same components shared between the two time points, and $_{a22}$ and e_{22} represent those components unique to time 2 measurements. Genetic effects on stability of the phenotype across time (genetic correlation) can be determined by the genetic covariance divided by the square root of the genetic variances of both traits as described by McCaffery et al. (2007), $a_{11}*a_{21}/ \sqrt{(a_{11}^2*(a_{21}^2 + a_{22}^2))}$ for the genetic correlation and $e_{11}*e_{21}/\sqrt{(e_{11}^2*(e_{21}^2 + e_{22}^2))}$ for the non-shared environmental correlation estimate Figure 4 displays the path estimates for Wave I and III bivariate models that demonstrate excellent fit, $\chi^2(14)= 8.57$, CFI = 1.00. Figure 5 shows the comparable model for Waves II and III, also yielding good fit, $\chi^2(14) = 13.49$, CFI = 1.00.

The above models showed the heritability of self-esteem at Waves I and II to be $a_{11}^2 = (.66)^2 = 44\%$ and $(.69)^2 = 48\%$, respectively. Wave III heritability estimates ($a_{21}^2+a_{22}^2$) in the models depicted in Figure 4 and 5 were $(.30)^2 + (.17)^2 = 12\%$ and $(.25)^2 + (.26)^2 = 13\%$, respectively. Bivariate estimates were similar to those yielded from the univariate models, bolstering their validity.

The estimated genetic correlation between Wave I and Wave III estimates was r = .87, while the non-shared environmental correlation between these time points was r = .13. The Wave II and Wave III genetic correlation estimate was r = .69 and the non-shared environment correlation was r = .16. The high genetic correlation of self-esteem across waves suggests that there is a common genetic influence on self-esteem in both adolescence and adulthood.

Discussion

Several important findings emerged from this behavioral genetic study of self-esteem. As previous research has shown, when self-esteem level is compared between twin pairs, the best fitting model includes an estimate of genetic contribution, with shared environment showing little to no contribution. Second, the additive genetic (or heritability) estimate for the latent (stable) self-esteem construct was larger than in previous reports. Third, although self-esteem shows moderate heritability at Waves I and II, at Wave III (early adulthood), self-esteem was not heritable and almost completely determined by unique environment. Furthermore, the latent construct of self-esteem across time has a higher heritability than each age examined separately. Finally, high genetic correlations and low

Figure 3. Bivariate twin model for the measures of self-esteem at two time points.

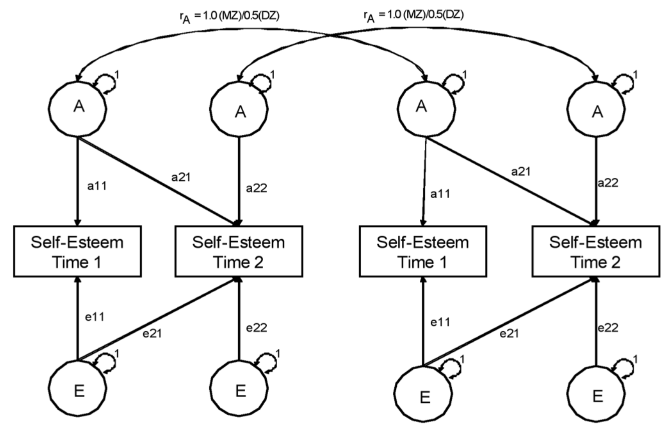


Figure 4. Bivariate twin model comparing self-esteem at Waves I and III.

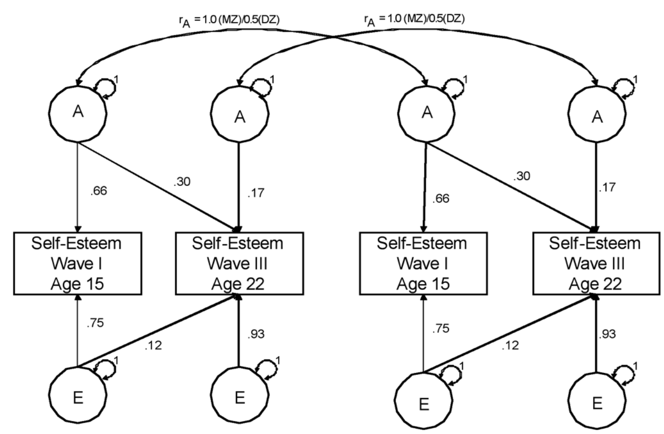
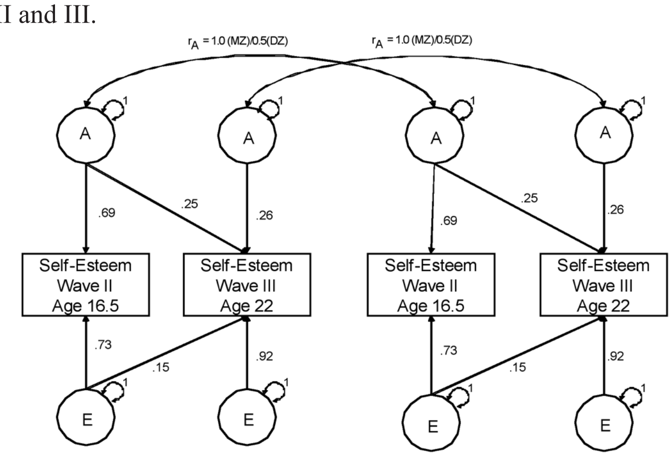


Figure 5. Bivariate twin model comparing self-esteem at Waves II and III.



unique environment correlations between self-esteem measurements suggests that the significant decrease in heritability estimates from Wave I to Wave III is due to an increase in unique environmental influences on self-esteem over time, rather than a decrease in the additive genetic effects.

The current study showed that siblings' shared environment accounts for a limited portion of the variance in self-esteem level. More parsimonious models excluding the shared environment parameter showed that self-esteem might only be influenced by additive genetic and non-shared environmental factors. Previous twin studies examining self-esteem have also found shared environment to be a non-significant contributor to self-esteem (Kamakura, Ando, & Ono, 2007; Kamakura, et al., 2001; Kendler, et al., 1998; McGuire, et al., 1994; Roy, et al., 1995). In the literature, as in the current study, AE models have been preferred. Despite consistency across findings, the limited power of twin studies to accurately estimate and detect modest effects of C in the presence of substantial genetic influences should be noted (Coventry & Keller, 2005; Keller & Coventry, 2005; Martin, Eaves, Kearsey, & Davies, 1978).

The self-esteem heritability estimate of 77% in the repeated measures model of the current study was higher than the 52% heritability estimate that was previously found in the repeated measures test by Roy et al. (1995). The use of three measurements, one and a half and six years after the initial measurement in the current study, as opposed to only two time points approximately 16 months apart in the Roy et al. (1995) study, may have contributed to the difference in estimates.

To determine if differences in the number of measurements and length of time between measurements may have contributed to the discrepancy between the current heritability estimates and those reported by Roy et al. (1995), a heritability AE model was run using only self-esteem measured at Wave I and Wave II. These self-esteem measures were taken about 18 months apart, utilizing a similar time increment and sample size as those reported by Roy et al. (1995). This model yielded adequate fit ($\chi^2 = 19.75$, df = 9, CFI = .98) and a heritability estimate of 61%, while unique environment accounted for 39% of the variance. This estimate, being lower and much closer to that reported by Roy et al. (1995), suggests that adding additional time points to the measurement of self-esteem may provide a better estimate of true self-esteem level and the underlying stability. Examining multiple measures of self-esteem—modeling a stable component across more than two measurements—appears to yield a more accurate estimate of the genetic contribution to self-esteem.

Although similar, heritability estimates for Wave I and II self-esteem measurements were still quantitatively greater than those reported by Roy et al. (1995). Higher estimates in the current sample may be due to greater heterogeneity in genetic background, as indicated by a larger racial and geographical representation, which may have resulted in greater genetic variance. Participants in the Roy et al. (1995) study were older (mean age = 30) and all Caucasian females. Findings from the current study suggest that heritability estimates may decrease with age; thus, lower estimates in an older sample would be expected.

Lastly, heritability estimates in the current sample were lower in the age-specific model than in the common factor model. It is probable that significant differences in the parameter estimates between univariate and multivariate models were due to measurement error. In the cross-sectional univariate models, E is confounded with short-term variations in self-esteem and random errors in measurement (Cronbach, 1970; Kendler, Neale, Kessler, Heath, & Eaves, 1993). The repeated measurements model has the advantage over the univariate models by allowing an examination of the component of self-esteem that is stable over three occasions, distinguishing random error and short-term fluctuations from longer term environmental influences (Kendler, et al., 1993). In contrast to Wave I and II, additive genetic effects did not significantly contribute (13%) to the variance of self-esteem at Wave III. To tease apart these interesting findings, in post hoc analyses, two bivariate models were tested using a 7 year and 5.5 year interval in self-esteem measurement. Heritability estimates in the bivariate models did not differ from those yielded in the univariate models. Further, in both bivariate models the genetic correlation of self-esteem was high (r = .87 and .69).

A recent study examined the heritability of self-esteem using a bivariate twin model (Kamakura, et al., 2007) among 100 male and female Japanese twin pairs. Self-esteem was measured at two time points, 1.3 years apart, and the average age of respondents was 19.8 years at time 1 and 21.1 years at time 2. In contrast to the current study, they found the heritability of self-esteem to increase in early adulthood from 31% to 49%. It is difficult to explain the differences in early adulthood heritability estimates between the current findings and those reported by Kamakura et al. (2007). Differences in sample size and the number of items used to measure self-esteem (4 vs. 10 items), are likely contributors to the discrepancy in findings. Moreover, cultural differences between the two samples (i.e. Japanese vs. American) may have also been a lead to some differences in results between the two studies.

The high genetic correlation between self-esteem measurements at 7 and 5.5-year increments suggests that the environmental influences rather than genetic effects are changing over time. This hypothesis is supported by the results reported by Kamakura et al. (2007) showing no unique genetic effects on self-esteem at their time 2 measurement but significant unique non-shared environmental effects at time 2. Non-shared environment influences could not be accounted for by one factor alone but showed significant change even over a short 1.3-year interval (as opposed to 5.5 and 7-year intervals examined in the current study) from late adolescence to young adulthood. In a review of the effects of socioeconomic status (SES) on self-esteem, Twenge and Campbell (2002) found that the effects of SES on self-esteem increased over time, having more of an effect in adulthood than in adolescence. Because SES is a distal factor, the above finding may suggest that several proximal environmental factors related to self-esteem (factors that may cluster within high or low SES environments), have an influence on self-esteem that is more pronounced in young adulthood than adolescence. This time dependent environmental effect could account for the decreasing heritability estimates over time observed in the current study.

Despite the interesting nature of these findings, the limitations of heritability models should be noted. Twin studies cannot determine the extent to which genes or environment actually determines a phenotype. Rather, the estimated heritability of a trait reflects how much of the total phenotypic variation in a population is attributable to an estimate of shared genes compared to an estimate of shared environment. Further, heritability estimates give no information concerning the extent to which gene-environment interactions could change the phenotype of interest. Future studies are needed that examine the effects of specific environmental variables, genetic polymorphisms, and their interaction on self-esteem level and change over time.

Conclusion

Overall, the heritability of self-esteem measured at a single time point in adolescence is low and decreases over time. This is likely due to an increase in the influence of unique environmental components with age. In contrast to single measurement models, common factor models of self-esteem, or models that measure self-esteem stability over time, yielded large heritability estimates. As has been suggested in previous reports, it may be more effective to examine self-esteem stability due to the labile nature of self-esteem level and greater predictive power of self-esteem stability estimates (e.g. Kernis, 2005; Kernis, Grannemann, & Barclay, 1989). In line with this literature, the current study has shown that larger heritability estimates are achievable by using multiple self-esteem measurements and modeling a latent stable self-esteem construct. Although self-esteem is largely influenced by unique environmental experiences that are not shared by siblings—an effect that significantly increases by early adulthood—there is an underlying stable component of self-esteem that is highly heritable. Genetic influences appear to contribute to stability whereas environmental factors largely contribute to change in levels of self-esteem over time for this age range.

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