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Gene–Environment Interplay in the Context of Romantic Relationships

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Abstract

A growing body of research supports an important role for genetic factors on intimate, romantic relationships. In this article, we review research that has examined the interplay between genetic and environmental influences on romantic relationships and the associations between relationship outcomes and important individual differences related to relationships. We first elaborate on how behavioral genetic and molecular genetic methods can be used to understand the etiology of relationship outcomes. We then review empirical studies that have examined gene-environment correlations and gene-by-environment interactions in predicting romantic relationship outcomes (e.g., relationship formation, relationship quality and functioning, relationship dissolution) and their association with the physical health, mental health, and well-being of relationship partners.

Researchers have long used genetically-informative family data to investigate the etiology of individual differences (e.g., intelligence, psychopathology, and personality). Biometric modeling with twin data, for instance, uses differences between identical (monozygotic, MZ, 100% of genes shared) and fraternal (dizygotic, DZ, on average 50% genes shared) twins to calculate additive genetic influences (often abbreviated as A), shared environmental (influences shared in common that make family members more similar, abbreviated C), and nonshared environmental (influences that are not shared and that make family members less similar, abbreviated E) influences on a phenotype [1]. An important advance in this work was the discovery that the variation in putatively “environmental” variables (like marital status or quality) could also be explained, to a certain degree, by genetic influences that differed among people [2]. That discovery opened up the possibility for new ways of examining the origins of stress within relationships and how it impacts other aspects of people’s lives, for instance, formally testing the idea that environmental stressors like the

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marital relationship, for instance, might trigger genetic influences on another phenotype (i.e., diathesis-stress model of psychopathology).

Methods for Studying Genetic and Environmental Influences: Application to Relationship Outcomes

One possible explanation for genetic influences on relationship outcomes is the presence of a gene-environment correlation (rGE), which refers to the fact that heritable characteristics of individuals are correlated with the environments that they encounter (e.g., marriage), making those environments in fact heritable [3]. There are three “causal” types of rGE: passive rGE, in which parents pass on heritable characteristics to the child that are correlated with the environments that the parent provides; evocative rGE, in which heritable characteristics of the individual “evoke” responses from the environment; and active rGE, which occurs when inherited tendencies lead an individual to pick certain environments (i.e., niche building). Because passive rGE requires two genetically related individuals (e.g., parent and child), active and evocative rGE are most relevant to the study of romantic relationships. Of note, rGE cannot be tested directly using a standard twin model. The presence of rGE can be assumed if there are non-zero estimates of heritability of environmental variables (e.g., relationship quality). Further, it is also possible to infer the presence of rGE by estimating a genetic correlation between two variables. A genetic correlation (ranging from -1 to $+1$) estimates the degree of overlap between the genetic influences on two (or more) variables; similar correlations are possible for shared and nonshared environmental overlap.

In contrast to rGE, which posits genetic influences on exposure to different environments, a gene-by-environment interaction (GxE) describes a situation in which genetic influences are moderated by the environment; that is, environmental factors, including environmental stressors, can “trigger” genetic influences on a phenotype. For instance, two individuals may have the exact same alleles (variants or copies of a gene) for a phenotype, but that gene will not ultimately lead to the phenotype unless the individual encounters a certain environment. GxE fits well with the *diathesis-stress* model of psychopathology, in which an environmental stressor (e.g., marital conflict) triggers a genetic predisposition for development of a disorder [4]. An example of what this might look like is given in Panel A of Figure 1, which plots hypothetical A, C and E influences on a phenotype as a function of relationship quality. As shown in Panel A, the A estimates are highest when relationship quality is lowest. Other theoretical models of GxE include the *social push* or *bioecological* theory, in which genetic influences on a phenotype are expressed in the most advantageous environment (see Panel B of Figure 1), and the *differential susceptibility* model (see Panel C of Figure 1), which posits that genetic influences are expressed at both extremely high and low ends of the environmental moderator [for a recent review of these models and quantGxE, see 5].

Although it was long thought that heritability estimates might be biased by unobserved GxE, it has only been in the last decade that it has been possible to use twin data to estimate quantitative gene-by-environment interaction (quantGxE). These estimates of GxE are not able to determine which particular genes may be susceptible to the environment, but they do

indicate the environmental contexts in which genetic and environmental influences may be enhanced or diminished. As shown in Figure 1, these biometric moderation models estimate genetic (A), common environmental (C), and unique environmental (E) influences on the phenotype of interest at different levels of a second moderator variable (in these examples, the environmental context is relationship quality). Of note, this statistical model for quantGxE also results in genetic and environmental correlations that can differ along the levels of the moderator just as the ACE components change as a function of the moderator.

In addition to quantGxE, researchers have also examined whether certain environments moderate the influence of *measured* genes, analyzed as interactions between measured genes and measured environments on the presence of a phenotype. Often the genes examined in these molecular GxE studies are candidate genes (hence, cGxE) chosen based on animal models or known action of certain neurotransmitters. To date, this work has been rife with difficulty, specifically the failure to replicate significant findings across research groups [6–8]. In studying GxE interactions, researchers have also highlighted the importance of selecting candidate environmental factors based on their empirical or theoretical importance [9].

Findings from Studies of rGE and GxE and Relationship Outcomes

We begin by reviewing the evidence for rGE and GxE for romantic relationships as the phenotype of interest. We then turn to findings from studies that focus on intimate relationship functioning as the candidate environment; in these studies, genetic and environmental influences on relationships may overlap with other phenotypes (e.g., personality), or relationships may moderate the impact of measured genes (cGxE) or genetic and environmental influences (quantGxE) on other phenotypes.

rGE Studies of Relationship Outcomes

Researchers have studied gene-environment correlations using genetically informative data for a variety of relationship outcomes, including divorce [10,11]. An early study found that genetic factors accounted for approximately 53% of the variance in divorce liability [10]. Some might be tempted to interpret this finding as suggesting there are “genes” for divorce; this is probably not likely, but instead related to other genetically-influenced characteristics of the individual. Personality characteristics, which have been shown to be highly heritable [12], are one of the major mechanisms that generate this association [13]. Interestingly, nonshared environment accounted for the rest of the variance in divorce. There are numerous possible environmental influences here, but one important one may be the personality of the spouse. Research has also shown that attitudes towards divorce are heritable, that genetic influences on such attitudes decrease following an actual divorce, and that the same genetic factors that contribute to attitudes toward divorce also contribute to the risk of divorce itself [14].

Genetic factors also influence the propensity to marry [11,15]. One study estimated that the heritability of propensity to marry was approximately 70%, and that genetic factors accounted for a portion of the variance between personality and propensity to marry [15]. Furthermore, genetic influences on the propensity to marry increase through middle age and

then decrease in older adulthood [16]. Interestingly, the propensity to marry seems to be due to distinct genetic and environmental influences from the propensity to divorce [11].

Researchers have also found evidence of gene-environment correlations for relationship quality. A study of female twins found that genetically influenced characteristics partially accounted for wives' and husbands' reports of marital quality and the overlap between spouses' reports [17]. However, both spouses' individual reports and the overlap between their reports were most strongly the result of environmental influences that are not shared between twins, which may reflect the influence of partners' (i.e., husbands') characteristics. A larger follow-up study found genetic influences on relationship quality were larger for self-report data than for observational data, and that twins' (but not partners') personality characteristics partially accounted for genetic and non-shared environmental influences on both spouses' self-reports and the overlap between spouses' reports [18]. In a replication and extension of this work in a separate sample, marital quality was shown to have genetic and nonshared environmental influences, with small gender differences in these influences [19]. Constructs related to marital quality, such as marital conflict, have also been shown to have genetic and non-shared environmental influences [20]. As pair-bonding behaviors, including partner bonding and marital problems, are associated with the vasopressin receptor 1a gene (AVPR1A) [21] and the oxytocin receptor gene (OXTR) [22], and cumulative risk on the OXTR is associated with difficulties in empathic communication in couples [23], these candidate genes may be sources of genetic influence on relationship quality and functioning.

GxE Studies of Relationship Outcomes

Researchers have also examined GxE interactions in predicting relationship outcomes. In one study, researchers created a genetic composite of allelic variation for polymorphisms of five genes and found that adults exposed to more hostile (or positive) parenting behaviors during adolescence engaged in more hostile (or positive) behavior toward a romantic partner if they scored higher on the genetic composite, suggesting that genetic factors moderated the association between experiences in the family of origin and subsequent relationship behaviors [24]. Another study found that young adults with higher genetic risk, measured across four genetic variants implicated in serotonin and dopamine transmission, were less satisfied with their romantic relationships if exposed to early life disadvantages (i.e., parental marital instability and community adversity) [25].

There is some evidence that genetic variation in the promotor region (5-HTTLPR) of the serotonin transporter gene moderates the association between emotional behavior and relationship outcomes. This polymorphism presumably influences the transcription rate of the serotonin transport (5-HTT) gene, with the short (S) allele being transcriptionally less efficient than the long (L) allele [26]. In one study, spouses rated their affective states before and after marital conflict and support discussions, and relative to spouses with two L alleles, spouses with one or two copies of the S allele were more responsive to their partner's positive and negative emotions, suggesting that genetic variation may impact the degree of emotional interdependence between partners [27]. Another study examined observer-coded behavior from a marital conflict conversation and found that higher negative and lower positive emotional behavior was associated with declines in marital quality over a 13-year

follow-up for individuals homozygous for the S allele but not for individuals with one or two copies of the L allele [28].

All of these findings can be considered measured genetic corollaries to the pattern of quantitative genetic influences shown in Panel A of Figure 1; that is, whereas Figure 1 displays how estimated genetic and environmental influences shift as a function of environmental stress, these GxE studies using measured genes focus on how the presence of a genetic risk (in the form of “risky” genetic profiles) plus environmental stress lead to worse outcomes. To date, the measured GxE studies all seem to follow a pattern of diathesis-stress (see Panel A of Figure 1); you can imagine that the high estimate of A influences on the far left hand side in Panel A is replaced by the “risk allele”, and that it is this allele plus environmental stress which lead to the negative end of the phenotype.

rGE and GxE Studies of the Interplay between Relationship and Individual Functioning

There is a robust association between poor relationship quality and psychopathology [29]. As results from twin [30] and molecular genetic [31] studies suggest that most forms of psychopathology are also influenced by genetic factors, genetic and environmental influences on relationship quality may overlap with genetic and environmental influences on psychopathology. In a study of female twins, there were shared genetic influences on the covariation between wives’ self-reported marital quality, social support, and depressive symptoms [32]. When analyses were based on husbands’ report of marital quality, there was evidence for shared genetic effects, suggesting that wives’ genetically influenced characteristics may impact her own and her husbands’ marital quality. There was also evidence of non-shared environmental influences on the covariation between marital quality and wives’ depressive symptoms, which may be due to husbands’ characteristics. Other studies have found evidence for overlap in the genetic influences on marital quality and internalizing disorders, but not evidence for non-shared environmental influences [33], and that the association between marital support and depressive symptoms was not an artifact of selection (i.e., people genetically prone to depression selecting less desirable partners, leading to poor marital quality), thereby supporting a quasi-causal interpretation for this association [34]. Finally, in a sample of males, there were genetic and nonshared environmental influences on the covariation between alcohol consumption and relationship quality, and genetic influences on the association between alcohol problems and relationship quality [35]; the finding that marital quality partially mediated the association between the AVPR1A gene and substance use disorders in males suggests this gene may be one source of this shared genetic influence [36].

It is well established that relationship quality covaries with indexes of subjective well-being such as life satisfaction [37], which themselves are influenced by genetic and environmental factors [38], and several studies have examined genetic and environmental influences on this association. One study found evidence for common genetic and nonshared environmental influences on the covariance between relationship quality and well-being, with evidence that partners were the source of the nonshared environmental influence [39]. In a study of male and female twin pairs and three indexes of well-being, the covariation between marital

quality and well-being was largely due to genetic influences for women and genetic and non-shared environmental influences for men [40].

In studying associations between relationship quality and psychopathology, researchers have also examined GxE interactions. Using a nationwide twin sample, one study reported that genetic influences on internalizing disorders were greatest when levels of marital quality were low, suggesting that people with a genetic liability to internalizing disorders may be at greater risk when they are in an unsatisfying marriage (evidence for diathesis-stress, see Panel A of Figure 1) [33]. Another study involving the same sample found non-shared environmental influences on alcohol use problems were greatest when levels of marital support were low, suggesting that when romantic partners provide low levels of support, unique environmental factors (such as influences from one's job or relationship with one's friends) contribute to problematic alcohol use (evidence of Bioecological model, see Panel B of Figure 1) [41].

Poor relationship quality is also associated with poor physical health [42]. Using the same nationwide twin sample, results suggested that the genetic and shared environmental influences on marital quality were the same as the genetic and shared environmental influences on self-rated health, whereas there was essentially no overlap in the non-shared environmental influences on marital quality and health [43]. Results also supported a GxE interaction, in which genetic influences on the variation in physical health were greatest at both high and low levels of marital quality and lowest at the average level of marital quality (evidence of differential susceptibility, see Panel C of Figure 1). With respect to health behaviors, one study found that the association between marital quality and sleep quality appears to be due to nonshared environmental influences, which may again reflect the influence of one's partner [44].

Conclusions

Research evaluating gene-environment correlations and gene-by-environment interactions has enhanced understanding of romantic relationship outcomes and their association with psychopathology, well-being, and physical health. It is worth noting that evidence for genetic influences on romantic relationships does not imply immutability [1]. Existing research forms a solid foundation for continued study of the interplay of genetic and environmental influences on romantic relationships and their association with individual functioning.

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Highlights

- Romantic relationships are key contexts for studying gene-environment interplay
- Gene-environment correlations (rGE) have been observed for relationship outcomes
- Gene-by-environment (GxE) interactions predict relationship outcomes
- GxE interactions and rGE have been found for partners' mental and physical health
- Behavioral and molecular genetic studies can inform understanding of relationships

Figure 1.

Possible examples of the pattern of genetic and environmental influences on a hypothetical phenotype resulting from quantGxE. Heritability (A) and proportions of variance due to shared environmental (C) and nonshared environmental (E) influence are plotted as a function of relationship quality, shown on the X axis at five different levels: -2 , -1 , 0 , 1 , and 2 Standard Deviations from the Mean. Example A follows the Diathesis-stress model, in which genetic influences are highest in the “riskiest” environment, here extremely low levels of relationship quality. Example B follows the Bioecological model, in which genetic influences on the phenotype are highest in the least risky environment of high relationship quality. Example C follows the Differential susceptibility model, in that genetic influences are highest in both the high risk and low risk environments. In these examples, we have artificially constrained C to 0, but several studies of quantGxE have found that C is substantially greater than 0, particularly in extreme ends of the environmental context.