



# Gene–environment interactions: Peers' alcohol use moderates genetic contribution to adolescent drinking behavior

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## ABSTRACT

Social context is increasingly recognized as essential for understanding complex human outcomes even among geneticists who focus on genetic influences. These outcomes typically involve multiple genes, multiple environmental factors, and the interactions between the two. In this paper, we propose a conceptual framework for gene–environment interaction and show how the interaction can be tested empirically using a sample of MZ twin, DZ twins, and full siblings. We test the hypothesis that the genetic contribution to adolescent drinking depends on the drinking behavior of their friends, using a sample of clusters of siblings and their friends from Add Health. Our analysis has yielded evidence supporting the gene–environment interaction hypothesis. High levels of alcohol use by one's best friend or among one's friends tend to bring about higher levels of genetic contribution to alcohol use. Lower levels of alcohol use by one's best friend or among one's friends tend to suppress the level of genetic contribution to alcohol use. Our findings suggest that friend behavior might be a particularly important environmental moderator of the expression of genetic disposition for adolescent drug use, smoking, dietary habits, and risky sexual behavior. Subsequent studies of these behaviors that use non-DNA twin samples or DNA measures of genetic variants should investigate peer influence as a significant environmental moderator.

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## 1. Introduction

Decades of efforts in molecular genetics have discovered more than a thousand genes responsible for Mendelian human outcomes—outcomes mostly determined by alleles of a single gene (Risch, 2000; Botstein and Risch, 2003). Examples of such human outcomes include Huntington's disease, cystic fibrosis, hereditary non-polyposis colon cancer, and heritable breast cancers. These diseases are rare in human populations and therefore explain relatively small portions of overall disease prevalence.

Molecular genetic efforts have been much less successful on Non-Mendelian or complex human outcomes. Many of these outcomes, including reading disability, smoking, alcohol use, drug use, and obesity, are of interest to sociologists. The links between genetic heritage and complex human outcomes are enormously complicated, typically involving multiple genes, environmental factors, and the interaction between the two.

There has been an increasing recognition that social scientists' expertise in social context is indispensable for understanding many of complex human outcomes (Caspi et al., 2002, 2003). The success of the Human Genome Project (Collins et al., 2003a) and the HapMap Project<sup>1</sup> (The International HapMap Project, 2003, 2005) is improving the design and effectiveness of

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<sup>1</sup> The International HapMap Project is a collaborative effort by scientists and funding agencies from Japan, the United Kingdom, Canada, China, Nigeria, and the United States. The purpose of the project is to identify and catalog genetic similarities and differences in human beings. The information from the HapMap will facilitate researchers in finding genes that affect health, disease, and individual responses to medications and environmental factors.

genetic studies. These advances, however, do not lessen the need to understand the environmental part of the puzzle. On the contrary, inadequate understanding of environment has increasingly become the bottleneck for the rapid technological advances in molecular genetics. Recently, the HapMap project (The International HapMap Consortium, 2005) and the National Human Genome Research Institute (Collins et al., 2003b) called for heavy investment in lifestyle factors and environmental exposures and in longitudinal studies of adequate size that would obtain such information.

In addition to contributing to work that focuses on genetic influences, sociologists may also be interested in incorporating the advances in molecular genetics into sociological thinking. Genes may be an important component of outcomes relevant to sociologists. Taking genetic heritage into account promises a fuller understanding of social outcomes and a more precise understanding of the roles of social context.

The objective of this study is two fold. First, we develop a conceptual framework for gene–environment interactions and indicate how the interaction can be tested empirically using a sample of MZ twins, DZ twins, and full siblings. Second, we apply this framework to test the hypothesis that the genetic contribution to alcohol use among adolescents depends on the drinking behavior of their friends. Data come from a sample of clusters of siblings as well as their friends collected by the National Longitudinal Study of Adolescent Health (Add Health) (Harris et al., 2003).

## 2. Background

### 2.1. Adolescent drinking

Alcohol consumption among the young remains a major public health problem in the United States (Johnston et al., 2003). The project Monitoring the Future, a nationally representative survey of 8th, 10th, and 12th graders, reveals a high prevalence of alcohol use and a trend toward earlier onset. Nearly 30 percent of 8th graders reported consuming alcohol in the previous 30 days, and 7 percent reported having been drunk during that time. About 29 percent of 12th graders reported binge drinking (i.e. having five or more drinks in a row) during the two-week period prior to the study. More noteworthy, the trend shows the onset of alcohol use at younger ages. Between 1987 and 1996, the average age at onset decreased from 18 to 16 (Office of National Drug Control Policy, 1997). In 1999, a third of youth surveyed reported beginning to drink before the age of 13 (CDC, 2000).

The initiation of alcohol use prior to age 15 is associated with an increased risk of alcohol-related problems later in life (Grant and Dawson, 1997). Alcohol abuse among adolescents is correlated with a variety of other risk behaviors, such as poor school performance, substance abuse, sexual activity, violence, delinquency, drinking and driving, tobacco use, and suicide (Windle, 1999, 2003). Heavy drinking is associated with Type II diabetes (e.g., Wannamethee and Shaper, 1992) and coronary artery disease, cardiac arrhythmias, and stroke, among other disorders (Puddey et al., 1999). Heavy drinking is also linked to morbidity and mortality through an increased risk of accidents (e.g., Hingson and Howland, 2002).

### 2.2. Sociological theories of peer influence, genes, and adolescent drinking

'Imitation' is a significant theme in Durkheim's classic *Suicide* (1897/1951) and defined as the social process spreading unstable and transitory social currents. Although Durkheim (1897/1951: 138–142) did not find empirical support for it as an explanation for suicide, he recognized imitation as a potentially potent force influencing social behavior. Peer influence occupies a particularly important place in Coleman's *The Adolescent Society* (1961) in which he focused on the leading crowd, or the most popular students, in a school who both reflect and influence the normative climate of the school. Durkheim's imitation corresponds closely to a prominent and long-standing theoretical tradition in the sociology of crime and deviant behavior (Allen and Wilder, 1977; Festinger, 1954; Akers, 1973, 1997; Sutherland and Cressey, 1984). A number of mechanisms within this tradition link peer influence to individual behavior, but the main argument is that associating with delinquent peers breeds delinquency.

The empirical evidence linking peer delinquent behavior and ego delinquent behavior such as drinking, substance abuse, and sexual behavior is among the strongest and the most widely reported in the social sciences (Kandel, 1975; Brown and Theobald, 1999; Billy et al., 1984; Billy and Udry, 1985; Ennett and Bauman, 1994; Yamaguchi and Kandel, 1987; Haynie, 2001, 2002; Haynie and Osgood, 2005; Warr, 1993; Warr and Stafford, 1991). Peers and friends are particularly important for adolescents who spend twice as much time each week with peers outside the family as do they with parents (Brown, 1990). One well-known position argues that socialization mainly takes place in the peer groups of childhood and adolescence and in comparison parents do not have any important long-term effects on child development (Harris, 1995). All of the contemporary social theories on peer influence and delinquency emphasize social proximity between the individual and his or her peers. However, an individual is not equally influenced by everyone in the population. The amount of influence depends on the strength of the social ties involved and most theories predict the largest influence from the best friend. In our analysis, we focus on the drinking behavior of best friend as a critical source of peer influence.

Twin and adoption studies have indicated the presence of genetic influences on various aspects of alcohol use and dependence, explaining about 50–60% of the variance in the alcohol measures (McGue, 1999; Tyndale, 2003; Dick and Foroud, 2003). Twin studies have shown that genetic factors play an important role in the initiation of drinking, early alcohol use, frequency of intoxication, frequency of alcohol consumption, average quantity consumed when drinking, the observed lon-

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