
The Minnesota Twin Registry: Current Status and Future Directions

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The Minnesota Twin Registry is a birth-record-based twin registry. Begun in 1983, it includes data for 4307 surviving intact pairs born in Minnesota between 1936 and 1955. In addition, the Registry includes 901 twin pairs born in Minnesota from 1904 to 1934, as well as 391 male pairs born in Minnesota from 1961 to 1964. The research focus is primarily on human individual differences assessed by self-report. Questionnaires completed by the participants include measures of personality, occupational interests, demographics, and leisure-time activities. We outline major contributions that have resulted from Registry research, as well as current and future research directions.

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Recruitment

Recruitment began with permission from the State Health Department to photocopy all birth certificates reporting multiple births. This photocopying process was made necessary because Minnesota birth records prior to 1959 had not been computerized. The information contained in Minnesota birth records varies slightly from year to year. Typically, however, it includes the child's name and sex, the name, age, race, and occupation of the father, the full maiden name, age, race, and occupation of the mother, the date, time, and place of birth, the number of living children born previously to this mother, whether this was a multiple birth and the birth order of this child, the birth weight and length, and the name of the attending physician, midwife, or other informant. Sets of records including one or more stillbirths or infant deaths and records of illegitimate births were discarded.

The next step was to search the state's death records for the 6 months following the birth in order to eliminate pairs that did not survive early infancy. Then, if the twins' parents were likely to still be living, attempts were made to locate them by using telephone directory listings beginning in the area where the twins were born. If this did not work, other people in the area with the same surname were contacted; they were often relatives. Directories organized by location and address were also used to identify persons now

living at the parents' former address; these people sometimes knew where the family of the twins had gone, or knew a long-term neighbor who might know. Other possibilities included the father's employer or the birth hospital.

When attempting to locate the adult twins directly, marriage records were used to identify female name changes. Then the state's driver's license records were generally searched. These techniques are less effective when the twins have moved out of state. Still, twin pairs representing about 80% of the intact pairs were located. Beyond this percentage, the cost and effort involved in locating additional pairs became prohibitive.

Once located, the Registry mailed the potential participants a 4-page Biographical Questionnaire (BQ) along with an introductory newsletter and a copy of a letter signed by Minnesota's governor urging participation. Sixty to 70% of individuals responded within 8 weeks. Those that did not respond were then contacted by telephone. Many of these persons had mislaid the questionnaire and were happy to complete a second copy when it was sent to them. Others still had the first copy and the phone call provided the incentive necessary for them to complete it. Two telephone prompts, 6 to 8 weeks apart, generally yielded return of the BQ from about 80% of the twins originally contacted.

On the second (and final) telephone prompt, twins who had not returned the BQ were originally told that their names would be entered in a lottery with a prize of \$1,000 if both members of their pair returned the questionnaire. This incentive was used only with the minority of reluctant twins who had indicated that they would not participate without some compensation. Thus the total sample consists of those who would normally participate in such studies, plus some additional participants who otherwise would not have been sampled. It is therefore more representative of the general population than many earlier volunteer twin studies.

The lottery was later abandoned because it was found to be illegal in many jurisdictions. It was replaced by direct payment of \$10 for participation to those who had not responded by the second telephone prompt.

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The initial request for information from the participants was rather modest, on the assumption that they would be more likely to continue to participate if requests for information were never time-consuming or onerous at any one time. This meant, however, that the Registry was dependent on maintaining participant interest in providing follow-up information for accumulation of a reasonable database. To accomplish this, each participant was mailed a computer-generated personalized report of his or her scores on about 60 factor-analytically derived dimensions of personality and interest. Newsletters containing reports on Registry activities and other information of interest to twins are mailed at irregular intervals to all participants.

Parents, spouses, same-sex siblings, and offspring of the Registry twins were also recruited, and their data are maintained in the Registry database, which also includes twins whose co-twin did not elect to participate. The family-member recruitments were based on the information provided by the twins in the BQ. Targets were parents when both were alive and well, same-sex singleton siblings when there were at least 2, and same-sex offspring of the twins (that is, same-sex pairs of cousins) aged at least 17. About 69% of spouses contributed data. Initially, the participation materials were distributed to the twins for relay to their families, but later experience showed that it was more effective to send the participation materials to the family members directly.

Zygosity determination was accomplished using self-reported answers to 5 questions in the BQ. These questions referred to similarity of eye and hair color, overall similarity in appearance, and the difficulty others encountered in distinguishing the twins. These questions were scored with positive points for responses indicating similarity and negative points for responses indicating differences. Pairs with mean scores of 4 or higher on these questions were classified as monozygotic (MZ) and all others were classified as dizygotic (DZ). Zygosity was also determined serologically for a subgroup of 74 pairs; the questionnaire approach was 96% accurate for this group.

Major Research Focus

The research focus in organizing the Registry is broad: human individual differences as assessed by self-report and collected by mail in order to maximize participation at minimal cost. The initial BQ's mailed to participants in the mid-1980s included information about educational level, occupation and income, marital status, offspring, composition of families, basic health, birth weight, gestational age, maternal age at birth of twins, height, weight, and shoe size.

Since then, many subsequent questionnaires have been completed by subsets of the twins. These include the Multidimensional Personality Questionnaire (MPQ; Tellegen, 1982), and questionnaires regarding occupational interests, leisure-time activities, talents, environmental assets (things such as reading materials and sports equipment available in the twins' homes currently and as children), mental habits, attitudes and opinions, handedness, closeness to twin, and moods. Registry subgroups have also completed specific questionnaires for special projects.

The birth cohort from 1904 to 1934 has completed a self-report assessment of depression symptomatology. A subgroup completed a follow-up in-person interview that lasted about 5 hours and included extensive assessment of intellectual functioning. Research with this birth cohort is focused on changes in personality and intellectual functioning with age.

The male birth cohort from 1961 to 1964 completed a 2-hour structured telephone interview that included a 35-item vocabulary test. Research with this birth cohort is focused on family demographics, environment, and relationships, and illegal and antisocial activities of the participants.

Our research approach is integrative: Registry data are combined and/or compared with those from other samples maintained at the University of Minnesota as available and appropriate. For example, Registry data are often combined and/or compared with those from the Minnesota Study of Twins Reared Apart (MISTRA; Bouchard, 1994) and the Minnesota Twin Family Study (MTFS; Iacono et al., 1999; see also Iacono et al., this issue).

Major Publications

Demographic Work

The initial work with Registry data was based on the BQ, as it provided the first data available. One of the first questions examined concerned the effects of the various incentives used to recruit Registry participants (Lykken et al., 1990). No significant differences were found in education, socioeconomic status (SES), or a variety of personality and interest factors between twin pairs concordant for ease of recruitment and those discordant. This suggested not only that the recruitment techniques used had not created distorting subgroups within the Registry sample, but also that in general, selection bias may not be a problem in research with adult twins when contacts are only by mail. Other initial questions examined included changes in neonatal mortality during the 45-year period from 1936 to 1981, height, weight, and body mass index (Carmichael & McGue, 1995), and the heritability of SES, educational attainment, fecundity, and risk of divorce.

Personality in General

The MPQ was the first questionnaire issued to Registry participants after the BQ, and it formed the core of the research program in the late 1980s and early 1990s. Much of this program was motivated by hypotheses generated by MISTRA, and these hypotheses required testing on large representative populations of middle-aged twins. Using both MISTRA and Registry data, Tellegen et al. (1988) established that the four-parameter biometric model including additive and nonadditive genetic components and shared and nonshared environmental components was necessary to provide an adequate fit for all of the 11 primary MPQ scales and their 3 higher-order factors. Heritabilities of the scales ranged from .39 to .58, and the shared environmental component was negligible for all but 2 of the scales. Three scales showed significant nonadditive genetic effects. This paper both established that the Registry and the MPQ would produce results consistent

with those of prior studies, and set the direction for the next several studies based on the Registry.

The importance of the nonadditive genetic component in biometric modeling of the MPQ scales and other traits measured in MISTRA and the Registry suggested that some traits are “emergenic” (Lykken, 1982; Lykken et al., 1993). That is, such traits are determined by the interaction of genetic influences rather than their sum. Thus, genetically identical MZ twins will tend to show high concordances for these traits while DZ twins may be no more similar than unrelated persons, and the combination of genes may be rare enough that the traits do not “run in families” even though they are highly genetic.

Extensions of Personality

This concept was extended from personality to interests and leisure-time activities as data from those questionnaires became available in the early 1990s. Lykken et al. (1993) established that about 50% of variance in interests was associated with genetic variation, and Waller et al. (1995) suggested that occupational interests, leisure-time activities, and personality are psychometrically separate domains, though they are related in meaningful ways. In the process, they introduced new methods for ipsative scaling and nonmetric multidimensional scaling, and proposed a model in which genetically influenced precursor traits of aptitude and personality guide the development of interests through the mechanisms of gene-environment interaction and correlation.

Sex differences in heritability of MPQ personality scale measures have also been investigated using the Registry. Finkel and McGue (1997) found significant sex differences in heritability for the Alienation, Control, and Absorption scales, as well as significant nonadditive genetic influence for all scales except Traditionalism and Absorption. A small subgroup of Registry participants completed the MPQ again, 10 years after the first completion. The average age was 20 at first completion and 30 at follow-up. Their data (McGue et al., 1993) showed significant mean decreases in Negative Emotionality, increases in Constraint, but no significant change in Positive Emotionality. Biometric analyses suggested that a decrease in the variance in Negative Emotionality was due to diminishing genetic influences, stability in personality was due to genetic influences, and personality change in adulthood largely reflected environmental influences.

Specific Aspects of Personality

Research efforts have also focused on specific aspects of personality. Using the Well-Being scale of the MPQ, Lykken and Tellegen (1996) measured happiness. The data showed that SES, educational attainment, family income, marital status, and religious commitment each failed to explain more than 3% of the variance in Well-Being. From 44–52% of the variance in Well-Being was associated with genetic variation, however. Based on retests of smaller samples after intervals of about 4.5 and 10 years, they concluded that the heritability of the stable component of Well-Being approaches 80%. This led to *Happiness: What Studies on Twins Show Us About Nature, Nurture, and the Happiness Set-Point* (Lykken, 2000b), in which Lykken described how nature and nurture work to affect our sense

of well-being, and how people can work effectively to influence their own happiness.

Another aspect of personality that has been studied using Registry data is Authoritarianism, which has historically been assumed to be the result of influences in the rearing environment. As described by McCourt et al. (1999), Registry and MISTRA data suggested that genetic factors accounted for about 50% and non-shared environmental factors accounted for about 35% of the variance in Authoritarianism, with either shared environment or assortative mating accounting for the remainder. Purportedly relevant environmental variables were associated with the Authoritarianism scores of the individuals reared by biological relatives, but this was not true for adoptees.

Effects of Aging

The 1904–1934 Registry cohort has been used primarily to investigate effects of aging on cognitive function. Among other projects, Finkel and McGue (1994) estimated that 55% of the variance in memory performance was genetic. They found that the relationship between memory and cognitive variables was primarily genetic in nature, while the relationship between memory and lifestyle variables was environmental in nature. Finkel and McGue (1998) found no age differences in the heritability of memory nor in the genetic and environmental mediation of the correlations between memory and other cognitive factors, though they did find age differences in the correlations themselves. This suggested that the natures of the relationships between memory and other cognitive factors were stable across age, though the extent of their relationships were not. Finkel et al. (1995) used 12 physiological, cognitive ability, and processing speed variables to describe functional age as a regression equation that predicted 66% of the variance in chronological age. The twin similarity data suggested that the relative genetic and environmental influences on the three principal components of functional age varied greatly.

Life Events

MISTRA data suggested the possibility that the occurrence of major life events has a heritable component. This was investigated with respect to divorce (McGue & Lykken, 1992) using Registry data. Concordance for divorce was significantly higher in MZ twins than in DZ twins, suggesting genetic influence. In addition, the family background of both spouses contributed independently to couples' risk of divorce, suggesting that divorce may commonly result from characteristics that each spouse brings to the marriage, rather than interaction effects. The specific aspects of personality contributing to divorce were investigated by Jockin et al. (1996). Positive and Negative Emotionality were positively related to risk of divorce, while Constraint was negatively related.

On the other hand, Registry data suggested that mate selection is not the result of heritable characteristics, either similar or dissimilar between spouses (Lykken & Tellegen, 1993). Neither spousal similarity nor idiosyncratic criteria among 74 mainly psychological variables could account for specific mate selection. A subgroup of the full sample also rated their attraction to their twin's mate or to their spouse's twin. The findings suggested that characteristics of both the

chooser and the chosen constrain mate selection only very weakly. Lykken and Tellegen proposed that romantic infatuation determines the final choice of mate from a broad field of potential eligibles, and that this phenomenon is effectively random.

Personality Structure and Links to Social Behavior

Recent areas of investigation using Registry data concern the structure of personality and links to social behavior. Using the Registry, Krueger (2000) showed that the underlying genetic and environmental structure of the MPQ scales mirror their phenotypic structure. He discovered Positive Emotionality, Negative Emotionality, and Constraint dimensions in patterns of phenotypic, genetic, and environmental correlations among MPQ scales. Extending this work, the etiologies of altruism and antisocial behavior were investigated by Krueger et al. (2001). Findings suggested that altruism and antisocial behavior are uncorrelated tendencies arising from different sources. Altruism was linked primarily to shared and nonshared environmental influences and MPQ Positive Emotionality, while antisocial behavior was linked primarily to genes, nonshared environments, MPQ Negative Emotionality and lack of MPQ Constraint.

Registry data have also been used to study the antecedents and correlates of antisocial behavior. Lykken (2000a) reported twin correlations along with mean scores and associated effect sizes for those scoring in the highest 25% and the lower 75% on a series of variables measuring MPQ Negative Emotionality and Constraint along with aspects of lack of socialization. The lack of socialization variables included admissions of illegal and antisocial activities, antagonistic relationships with parents, delinquency and violence of friends, lack of religious commitment, and lack of parental commitment during youth.

Future Plans

A wealth of additional Registry data have already been accumulated and await further analysis. Currently, there are projects in progress involving changes in MPQ scale scores across the lifespan, the inter-relationships of marriage and personality, and the personality antecedents of leadership behavior. Other projects in the planning phases include the development of masculinity and femininity scales based on interest inventories and longitudinal analysis of MPQ scale scores in participants over the age of 55.

In addition, we plan to use the Registry in a psychobiological investigation of the externalizing dimension of psychopathology discussed by Krueger (1999; Krueger et al., 2002). The project is based on the idea that externalizing is a broad vulnerability that underlies psychopathological syndromes involving antisocial behavior and substance dependence as well as personality traits reflecting impulsivity and disinhibition. The first specific objective is to develop and operationalize a hierarchical model of externalizing behavior that defines the core vulnerability construct and its distinctive behavioral manifestations from the normal through the abnormal range. This involves development of a self-report instrument to measure externalizing characteristics of individuals on a broad continuum. After initial

development and refinement, the inventory will be mailed to Registry participants. The data they provide will make it possible to confirm the psychometric properties of the externalizing inventory in a general population sample, as well as to assess the extent to which the self-report externalizing inventory maps underlying genotypic externalizing structures.

It is almost 20 years since work began to establish the Minnesota Twin Registry. In that time, the Registry has yielded a large volume of psychological data and important research findings. The Registry remains a valuable research tool with bright prospects for important future contributions to our understanding of human individual differences.

Acknowledgments

Robert F. Krueger was supported by National Institute of Mental Health Grant MH65137. The establishment of the Minnesota Twin Registry was supported by National Institute of Mental Health Grant MH37860 to David Lykken. We thank David Lykken for his helpful comments on a previous draft of this article.

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