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Suicidal behaviour: an epidemiological and genetic study

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ABSTRACT

Background. Psychiatric history, familial history of suicide attempts, and certain traumatic life events are important predictors of suicidal thoughts and behaviour. We examined the epidemiology and genetics of suicidality (i.e. reporting persistent suicidal thoughts or a plan or suicide attempt) in a large community-based sample of MZ and DZ twin pairs.

Method. Diagnostic telephone interviews were conducted in 1992–3 with twins from an Australian twin panel first surveyed in 1980–82 ($N = 5995$ respondents). Data were analysed using logistic regression models, taking into account twin pair zygosity and the history of suicidality in the respondent's co-twin.

Results. Lifetime prevalence of suicidal thoughts and attempts was remarkably constant across birth cohorts 1930–1964, and across gender. Major psychiatric correlates were history of major depression, panic disorder, social phobia in women, alcohol dependence and childhood conduct problems. Traumatic events involving assault (childhood sexual abuse, rape or physical assault) or status-loss (job loss, loss of property or home, divorce), and the personality trait neuroticism, were also significantly associated with suicide measures. Prevalence of serious suicide attempts varied as a function of religious affiliation. After controlling for these variables, however, history of suicide attempts or persistent thoughts in the respondent's co-twin remained a powerful predictor in MZ pairs (odds ratio = 3·9), but was not consistently predictive in DZ pairs. Overall, genetic factors accounted for approximately 45% of the variance in suicidal thoughts and behaviour (95% confidence interval 33–51%).

Conclusions. Risk of persistent suicidal thoughts and suicide attempts is determined by a complex interplay of psychiatric history, neuroticism, traumatic life experiences, genetic vulnerability specific for suicidal behaviour and sociocultural risk or protective factors.

INTRODUCTION

In many countries, suicide is one of the leading causes of premature mortality (Diekstra & Gulbinat, 1993). The annual incidence of completed suicide in industrial, Westernized countries is reported to be around 12 per 100000 of population (Diekstra, 1989). Lifetime prevalence of attempted suicide is reported to be between 1·1% (Paykel *et al.* 1974) and 4·3% (Moscicki, 1989) per annum. Suicidal plans and thoughts represent less severe forms of suicidal behaviour. The lifetime prevalence of suicidal plans has been estimated to be 2·6% (Paykel *et al.* 1974) while estimates for suicidal thoughts range from 4·8% (Paykel *et al.* 1974) to 15·9% (Schwab *et al.* 1972). Risk factors for suicidal behaviour include family history (familial aggregation) the presence of psychiatric and addictive disorders (co-morbidity) (Moscicki,

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1989) and psychosocial and personality factors (Cross & Hirschfeld, 1986).

Suicide often aggregates in families. Individuals contacting suicide prevention centres and patients hospitalized for attempted suicide have reported family histories of both completed and attempted suicides (Robins *et al*. 1957; Murphy *et al*. 1969; Murphy & Wetzel, 1982). Psychiatric patients with family histories of suicide are more likely to have attempted suicide compared with psychiatric patients without family histories of suicide (Roy, 1983). Similarly, relatives of patients who commit suicide are themselves more likely to commit suicide than relatives of patients who do not commit suicide (Tsuang, 1983). These studies suggest that familial factors may be involved in suicidal behaviour but do not allow clear conclusions to be drawn about the relative importance of environmental influences (such as exposure to the suicidal behaviour of other family members), as compared with the possible importance of genetic factors, in determining whether an individual will engage in suicidal behaviours. Increasingly, attempts have been made to clarify the relative importance of genetic *versus* environmental effects by controlling for environmental influences. A study of the prevalence of suicide within the Old Order Amish community in Pennsylvania, USA – a highly homogeneous religious community with clearly delineated family pedigrees, a high degree of social cohesion, little marital separation or divorce, or drug and alcohol abuse, and little unemployment – showed that suicides in this group did not occur randomly. Almost three-quarters of suicides clustered in only four family pedigrees, all of which also had a heavy loading for a major affective disorder (Egeland & Sussex, 1985).

Results of adoption studies suggest that genetic factors, rather than familial environmental factors, are the major determinants of familial concordance for suicidal behaviour. Schulsinger *et al*. (1979) reported a higher incidence of suicide in the biological relatives of adopted suicide victims compared with biological relatives of matched, non-suicide controls, with no differences between the adoptive relatives of the suicide victims and relatives of the controls.

Twin studies, which compare the concordance rate between identical (monozygotic, MZ) and non-identical (dizygotic, DZ) twins have consistently shown a higher concordance rate for suicidality in MZ twins compared with DZ twins suggesting that genetic factors are important. Probandwise concordance rates for MZ twins range from 11% (Kallman, 1953, cited in Lester, 1986) to 56% (Roy *et al*. 1995). For DZ twins, one study obtained a probandwise concordance rate of 3% (Roy *et al*. 1991) while others did not obtain any concordant DZ pairs (Haberlandt, 1967, cited in Roy, 1988; Juel-Neilsen & Videbech, 1970; Kallman, 1953, cited in Lester, 1986; Roy *et al*. 1995).

Studies of suicidality have consistently demonstrated that suicidal behaviour most often occurs within the context of psychiatric illness. The predominance of depressive disorders in suicidality has been clearly established (Asgard, 1990; Petronis *et al*. 1990; Henriksson *et al*. 1993; Cheng, 1995; Beautrais *et al*. 1996) as has the role of alcoholism (Murphy & Wetzel, 1990; Roy *et al*. 1990; Murphy *et al*. 1992; Cornelius *et al*. 1996). The presence of social phobia and/or panic disorder also increases the risk of suicidal behaviour (Weissman *et al*. 1989; Cox *et al*. 1994; Hirschfeld, 1996) particularly in combination with affective disorders and alcoholism (Lepine *et al*. 1993; Florequin *et al*. 1995; Lish *et al*. 1996). In addition to co-morbid disorders of depression, anxiety and alcoholism, suicidality has also been related to conduct disorder and antisocial personality disorder (Whitters *et al*. 1987; Allebeck *et al*. 1988; Brent *et al*. 1993; Apter *et al*. 1995; Young *et al*. 1995). Family and adoption studies (Schulsinger *et al*. 1979; Tsuang, 1983; Egeland & Sussex, 1985; Wender *et al*. 1986) and twin studies (Haberlandt, 1967, cited in Roy, 1988; Juel-Nielsen & Videbech, 1970; Roy, 1985; Roy *et al*. 1991) also show a strong association between psychiatric disorder and suicidality. Since risk of these disorders is to varying degrees influenced by genetic factors, the extent to which the genetics of suicidality is explained by genetic influences on risk of psychiatric disorder has not yet been adequately resolved. Results from a family study of adolescent suicide probands and their first-degree relatives (Brent *et al*. 1996) suggest that there may be significant familial aggregation of suicide attempts (but not suicidal ideation) even when psychiatric history is controlled for, but they do not address the question of genetic aetiology.

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In addition to psychiatric co-morbidity constituting a risk factor, vulnerability to suicidality may also be influenced by psychosocial and personality factors. Attempted suicide has been shown to be related to loss events (bereavement, marital separation) (Smith *et al*. 1988), physical and sexual assault and abuse (Gould *et al*. 1994; Davidson *et al*. 1996) and sociodemographic disadvantage (low education and income and high mobility) (Beautrais *et al*. 1996). Suicidality has also been related to childhood temperament (Caspi *et al*. 1996) and personality characteristics such as neuroticism and psychoticism (Irfani, 1978; Dyck, 1991; Nordstrom *et al*. 1995).

Much of the available data on the predictors of suicidal thoughts and behaviours derives from work on clinical samples, making it difficult to draw conclusions about the determinants of suicidality in the general population. To the extent that data have been obtained from population samples, they have typically been obtained in the context of studying a specific diagnosis (e.g. major depression), and have not usually been informed by the assessment of familial history of suicidality. The goal of the present study was to investigate the epidemiology and genetics of suicidal thoughts and behaviour in a community-based volunteer twin sample, using methods that would permit estimation of the effects of psychiatric history, personality, familial history of suicidality, and certain environmental risk and protective factors, in the statistical prediction of suicidal thoughts and attempts.

METHOD

Sample

Subjects were adult twins registered with the volunteer Australian National Health and Medical Research Council (NH & MRC) Twin Registry (ATR) and were in almost all cases of European descent. Recruitment of the current sample began in 1979–81 when 206 twin pairs participated in an alcohol challenge study (Martin *et al*. 1985*a*, *b*). In 1980–81 a mailed questionnaire survey was conducted (described in Jardine & Martin, 1984; Heath *et al*. 1995) with 8183 individuals (3808 pairs, 567 single twins) from the ATR, including 280 individuals (132 pairs and 16 single twins) from the alcohol challenge study. In 1988–9 a follow-up questionnaire was mailed to all twin pairs who completed the 1980–81 survey (Heath *et al*. 1994) with data obtained from 6327 individuals. Subjects were selected for the current telephone interview study if at least one twin in each pair had completed the 1988–9 survey or they had participated in the 1979–81 alcohol challenge study. As described in greater detail elsewhere (Heath *et al*. 1997), telephone interviews were conducted with 5995 individuals during 1992 and 1993. Interviews were completed with both members of 2718 pairs – 938 monozygotic (MZ) female, 401 MZ male, 539 dizygotic (DZ) female, 236 DZ male and 604 unlike-sex pairs – as well as 559 single twins (119 MZ female, 81 MZ male, 106 DZ female and 77 DZ male from same-sex pairs, 176 DZ from unlike-sex pairs). This sample included 106 accidentals – individuals who had responded to the mailed questionnaire in 1980–81 but had not participated in either the alcohol challenge study or the 1988–9 mailed survey and who, therefore, should not have been eligible for follow-up. Non-participants in the study included 78 individuals who were deceased, 144 lost to follow-up, and 554 (8·1%) who refused to be interviewed.

Zygosity was determined by self-report questionnaire using items which have been found to give at least 95% agreement with zygosity assignment by genotyping (Eaves *et al*. 1989). The validity of determining zygosity by questionnaire was examined for this sample by typing DNA specimens from a subsample of 190 of the same same-sex twin pairs who were also participating in a twin study of asthma. Using polymerase chain reaction (PCR), DNA typing with simple random repeat (STR) polymorphic markers was performed (Duffy, 1994). Twins were classified as MZ if they were concordant for at least eight unlinked DNA micro-satellite markers, while DZ twins were discordant for at least two unlinked markers (Duffy, 1994). Of the 190 pairs tested, there was 100% reliability between classification of zygosity based on questionnaire responses and classification based on DNA typing.

Assessments

1981 Survey

The 1981 mailed questionnaire survey (actually conducted in 1980–82) included the full-length Eysenck Personality Questionnaire (Eysenck &

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Eysenck, 1975), comprised of Neuroticism, Extraversion, Toughmindedness ('Psychoticism') and Social Non-conformity ('Lie') scales. The Neuroticism scale, in particular, has been found in other research studies to be a strong correlate of genetic risk of depression (Jardine *et al.* 1984; Kendler *et al.* 1993). Also included in the 1981 survey was a measure of state depression (see Kendler *et al.* 1986), which included a single item about current suicidal thoughts: 'Recently I have been so depressed that I have thought of doing away with myself'. Analysed in conjunction with follow-up data from the diagnostic interview, this provided information about the extent to which past suicidal ideation may be denied or forgotten by subjects.

1989 Survey

The 1989 mailed questionnaire survey (actually conducted in 1988–90) included a brief 10-item traumatic life events inventory, adapted from a similar instrument used in studies of the Virginia twin panel (Kendler *et al.* 1995*a*, *b*). Women only were asked to indicate whether they had EVER experienced a series of events: major loss of property or home; loss or decrease of job status; life-threatening accident; serious illness of loved one; sudden death of loved one; loss of child; broken marriage or engagement; life-threatening illness; rape or sexual assault; other physical assault; loss of a pregnancy; problems of infertility. No information about the timing of events was collected. In addition, the same state depression measure used in the 1981 survey was administered to all respondents (including men).

1992–4 Diagnostic Interview Survey

The interview instrument used was the SSAGA-OZ, a modified version of the SSAGA (Semi-Structured Assessment for the Genetics of Alcoholism), which was originally developed for a multi-centre genetic study of alcoholism, the Collaborative Study on the Genetics of Alcoholism (COGA). This measure is a comprehensive psychiatric interview designed to assess the physical, psychological and social manifestations of alcoholism and psychiatric disorders in adults (Bucholz *et al.* 1994). Inter-rater reliability of the instruments was excellent, as reviewed in Bucholz *et al.* (1994). The instrument was designed to be polydiagnostic but as adapted for use in the present study, diagnoses were based on DSM-III-R criteria (American Psychiatric Association, 1987), except in the case of major depression, where DSM-IV criteria for a major depressive episode were used, with the requirement that respondents report impairment or treatment for depression (see Bierut *et al.* 1998), and with transient bereavement episodes excluded.[1]

The SSAGA was modified for the current study by changing the wording from American-English to Australian-English and was adapted for telephone administration. Some diagnostic sections in the original SSAGA and non-DSM-III-R assessments, were excluded from the modified version. The SSAGA-OZ included diagnostic sections for alcohol dependence and abuse, major depression, childhood conduct disorder, mania, panic disorder, agoraphobia, and social phobia. The assessment of mania was non-diagnostic, but respondents were considered 'positive' for mania if respondents reported a week or more of euphoria and psychiatric treatment for this condition and if clinician review of interviewer notes confirmed an apparent history of bipolar disorder. Two additional sections asked questions about parental history of alcohol problems and parental history of major depression. A positive history was inferred if at least one twin reported parental problems.

Suicidality assessment

The suicidal behaviour section from the SSAGA was administered to all respondents. Questions focused on four central aspects of suicidality: suicidal thoughts, persistent suicidal thoughts (lasting more than one day), suicidal plans and suicide attempts. All questions were asked on a lifetime basis. In addition, there were questions regarding treatment and hospitalization for suicide attempts, as well as suicides and attempted suicides by the subjects' twin, mother, father, siblings and spouse and more remote relatives. A parental suicide attempt was inferred if at least one twin reported a parental suicide

[1] No attempt was made to identify cases with depressive symptoms that were secondary to the direct effects of a drug or medical condition, since it was not felt that this determination could be made satisfactorily based on reports by lay interviewers.

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attempt.[2] For purposes of the analyses presented here, suicide attempts were classified as serious if the respondent reported either a definite intent to die, or a method classified as of at least moderate lethality (e.g. at least briefly unconscious). For some genetic analyses, suicidality was assessed as a 4-point scale: (1) no suicidal thoughts reported; (2) transient thoughts only; (3) persistent thoughts or a plan or minor attempt (PT/P/A); or (4) a serious attempt (SA).

Quality control

The interviews, which averaged 38 min in length (range: 15–135 min), were conducted by lay interviewers who had received 40 h of training in structured interviewing techniques and the administration of the SSAGA-OZ. To ensure that each interviewer remained blind to the psychiatric status of the co-twin and to avoid inadvertent breaches of confidentiality, each member of a twin pair was interviewed by a different interviewer. To maintain a high level of quality control in terms of monitoring interviewers' performance, and to resolve difficulties in coding responses, all subjects were asked for permission to tape record the interview. Ninety-seven per cent of interviews were tape-recorded. The main method of quality control was an editing process which involved listening to the tape recording of the interview in conjunction with the completed interview booklet. A random 5% of interviews were edited in this way. In addition, all interviews were reviewed either by the project co-ordinator (a clinical psychologist) or by the most skilled interviewers (those who consistently had a low error rate for coding), and coding difficulties were resolved before computer entry. Reviewing/editing was always done by a person other than the interviewer who conducted the interview.

Data analysis

Estimates of lifetime prevalence were computed by gender and birth cohort both for measures of suicidal thoughts and behaviour, and for key psychiatric predictors of suicidality (history of major depression, childhood conduct disorder and alcohol dependence). Logistic regression analysis was used to examine the association between suicidal behaviour measures and socio-demographic, personality, psychiatric, traumatic event and family history predictor variables. In the case of analyses incorporating information about the co-twin's self-report suicidality, a set of dummy variables was used to code co-twin's history of suicidality as a function of twin pair zygosity. For continuous predictor variables, odds ratios (OR) were computed for a change in score equal to the interquartile range in women.[3] Bootstrapped 95% confidence intervals (CI) were computed for ORs, to adjust for the statistical non-independence of observations on twin pairs (Efron & Tibshirani, 1986), by resampling with replacement twin pairs where at least one twin participated in the follow-up interview. A total of 3000 bootstraps was conducted for each analysis. Standard genetic model-fitting procedures (e.g. Kendler *et al.* 1986; Neale, 1997) were also used to obtain estimates of the proportion of the total variance in suicidal thoughts or behaviour that could be explained by additive genetic factors, environmental factors shared by members of a twin pair (e.g. early home environment, rearing history), and non-shared environmental influences (i.e. environmental influences not shared by twin pairs). Estimates were obtained under a multifactorial threshold model, which assumes a continuous normal liability distribution underlying the observed binary measures of suicidal thoughts or behaviour. Models were fitted to twin pair contingency tables by the method of maximum likelihood (Eaves *et al.* 1978; Neale, 1997). Likelihood-based 95% CI were also computed (Neale & Miller, 1997), using MX (Neale, 1997).

RESULTS

Sample characteristics

The mean age of respondents participating in the long-term follow-up interview survey was 44·5 years in women (range 27–89) and 42·3 years in men (range 28–85). Although the

[2] Agreement between twins in reporting a parental suicide attempt was excellent (maternal attempt, kappa = 0·78 ± 0·11; paternal attempt, kappa = 0·93 ± 0·07).

[3] We used the interquartile ranges for one gender to avoid creating gender differences in reported odds ratio statistics that were purely a function of gender differences in the interquartile range.

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Table 1. *Lifetime prevalence (%) in women (W) and men (M) of suicidal thoughts and behaviour and of major depression, conduct disorder and alcohol dependence, as a function of birth cohort*

	Suicidal thoughts		Persistent thoughts		Suicide plan		Any attempt		Serious attempt		Major depression		Alcohol dependence		Childhood conduct disorder	
	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M
Pre-1930	12·4	9·3	2·8	3·1	1·7	3·1	1·5	0·5	0·6	0·5	15·0	10·3	0·7	7·3	0·0	4·7
1930–39	18·7	23·0	9·3	7·5	7·0	5·2	2·5	1·2	2·5	0·6	23·3	13·2	4·2	14·9	1·9	7·5
1940–49	22·5	22·4	8·9	8·6	6·9	6·6	3·4	1·8	2·4	1·3	24·9	16·4	4·7	22·6	1·7	18·3
1950–54	27·0	28·2	9·6	8·4	6·7	4·8	4·3	2·0	2·8	1·8	24·1	17·5	7·2	25·6	1·1	15·7
1955–59	24·5	28·2	9·6	10·1	6·6	6·7	3·9	3·0	2·3	3·0	21·9	17·7	7·2	32·3	4·1	19·5
1960–64	24·3	23·4	8·0	8·3	6·7	6·0	2·3	2·3	1·5	1·8	18·9	13·3	10·1	24·8	4·5	21·9

Australian National Health & Medical Research Council Twin Register from which the original sample was drawn is a volunteer twin panel, with over-representation of better-educated respondents (Baker *et al.* 1996), the full range of educational and socioeconomic backgrounds was represented in the sample. Some 30·4% of women respondents and 14·9% of men respondents had completed 10 or fewer years of education at the time of the original questionnaire survey in 1980–82, but 20·0% of women and 36·0% of men had completed at least some tertiary education. Fifteen per cent of women and 23·8% of men respondents were classified into the three highest or professional occupational grades of the Australian Congalton scale of occupational status, while 10·2% and 9·3% were classified into the two lowest grades (Congalton, 1963).

Lifetime prevalence of suicidality

Among women, 22·2% reported that they had had suicidal thoughts, 8·1% reported thoughts that persisted for more than a day, 6·2% reported suicidal plans and 3·0% one or more suicide attempts (but only 2·0% reported suicide attempts that were rated serious). Rates reported by male respondents were very comparable: 23·8, 8·2, 5·7, 2·0 and 1·7% respectively. With the exception of any suicide attempts, which were significantly less commonly reported by men (OR = 0·62, 95% CI 0·43–0·88), there were no significant sex differences, and this absence of any sex difference was in every case consistent across birth cohorts ($P > 0·2$ in all cases). In both sexes, 45% of those reporting attempts were hospitalized, and similar proportions in each sex reported making more than one suicide attempt (31% of women attempters, 26% of male attempters). The vast majority of those making suicide attempts reported being depressed at the time of their suicide attempt (89% of women, 98% of men), some also or only reported drinking at that time (13% of women, 24% of men). A drug overdose was the most commonly reported method (81% of women, 55% of men), with an additional 12% of women, 24% of men reporting cutting their wrists, using firearms, or inhalation of carbon monoxide, the remainder other methods.

Table 1 summarizes lifetime prevalence of suicidal thoughts and behaviour by birth cohort.

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Also given for comparison in Table 1 are the lifetime prevalence of major depression, alcohol dependence and childhood conduct disorder for the same birth cohorts. Compared with more recent cohorts, the oldest cohort of respondents, born prior to 1930, reported significantly lower lifetime prevalence of suicidal thoughts (OR = 0·45, 0·35–0·58), persistent thoughts (OR = 0·32, 0·19–0·53), suicide plans (OR = 0·31, 0·18–0·54), and any suicide attempt (OR = 0·63, 0·44–0·90) or serious attempt (OR = 0·28, 0·10–0·76). Rates of respondents reporting any suicidal thoughts were also significantly heterogeneous among the post-1930 cohorts ($\chi^2 = 16{\cdot}66$, df = 4, $P = 0{\cdot}002$), with an increase in lifetime prevalence for birth cohorts through the 1950s. With these exceptions, lifetime rates of suicidal thoughts and behaviour were remarkably constant across birth cohort, with no significant difference in lifetime rates ($P > 0{\cdot}2$ in all cases). This was particularly surprising in view of the more marked secular changes in lifetime rates of alcohol dependence (women, $\chi^2 = 49{\cdot}06$, df = 1, $P < 0{\cdot}001$; mean, $\chi^2 = 34{\cdot}50$, df = 1, $P < 0{\cdot}001$) and conduct disorder (women, $\chi^2 = 31{\cdot}64$, df = 1, $P < 0{\cdot}001$; men, $\chi^2 = 33{\cdot}19$, df = 1, $P < 0{\cdot}001$). For major depression, the only significant cohort differences in lifetime rates were a significantly reduced rate in the oldest cohort in women (OR = 0·58, 0·43–0·70) and an increased rate in men born 1950–59 (OR = 1·37, 1·06–1·76).

Reliability of reports

Of those who had endorsed the single suicidal thoughts item in the 1981 survey, 44% of women and 32% of men, denied experiencing such thoughts at interview follow-up. Nonetheless, the degree of agreement between report of current suicidal ideation in 1981, and lifetime suicidal ideation in 1992–3, was moderately strong (tetrachoric correlations ± standard error: women, 0·42 ± 0·04; men, 0·49 ± 0·06; kappas = 0·11 ± 0·02, 0·10 ± 0·02). A higher level of agreement was observed for those who endorsed the same item in the 1989 survey, with 78% of women and 76% of men reporting any suicidal thoughts at follow-up (tetrachoric correlations 0·65 ± 0·03, 0·61 ± 0·05; kappas = 0·22 ± 0·03, 0·18 ± 0·02). Agreement was still further increased for those who reported current suicidal thoughts 'a lot' or 'unbearably' in the 1989 questionnaire survey, with 87% of these women and 89% of these men reporting lifetime suicide thoughts at follow-up.

Family history effects

The association between family history of completed or attempted suicide, as reported by the respondent or his or her co-twin, and the severity of the respondent's suicidal thoughts or behaviour, is summarized in Table 2. Highly significant linear trends were observed in the case of family history of suicide attempts, with the proportion of respondents reporting a relative who committed suicide increasing by more than three-fold between those reporting a serious suicide attempt, compared to those reporting no suicidal thoughts; by more than six-fold in the case of those reporting a relative who attempted suicide, four-fold for reports of a maternal suicide attempt, and three-fold for reports of a paternal suicide attempt.

Also shown in Table 2 are the associations between respondents's suicidality and maternal and paternal history of depression and alcoholism. Highly significant associations were again observed, with reporting of maternal alcoholism increased over three-fold in those with a history of one or more suicide attempts. Two-thirds of serious attempters reported a maternal history of depression, and one-third each reported paternal history of depression and of alcoholism. In a multiple logistic regression analysis, controlling for birth cohort, primary family history determinants of making a serious attempt were relative's suicide attempt (partial OR = 2·23, 1·71–2·91), maternal depression (OR = 1·65, 1·44–1·88), paternal depression (OR = 1·42, 1·23–1·64) and paternal alcoholism (OR = 1·42, 1·22–1·64).

Psychiatric history

Table 3 summarizes the association between psychiatric history and suicidal thoughts and behaviour. The first four columns summarize the associations between individual disorders and reporting persistent thoughts or any plan or attempt (PT/P/A), or a serious suicide attempt (SA), controlling for birth cohort, but without controlling for the effects of co-morbid disorders. The next four columns examine the joint associations of these disorders (i.e. their partial associations) with suicidal thoughts and be-

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Table 2. *Respondents' history of suicidal thoughts and behaviour as a function of family history of suicide attempts and of maternal and paternal histories of depression and alcoholism*

	Familial suicide attempts				Parental psychopathology			
Respondent's suicidality	Relative† committed suicide %	Paternal suicide attempt %	Maternal suicide attempt %	Other relative attempted suicide %	Paternal depression %	Maternal depression %	Paternal alcoholism %	Maternal alcoholism %
No suicidal thoughts	0·6	1·0	2·3	3·1	23·5	33·2	19·7	4·2
Transient suicidal thoughts only	0·9	1·7	3·1	5·3	30·6	43·8	25·6	5·8
Persistent suicidal thoughts, plan or minor attempt	1·5	2·3	5·4	8·8	37·2	48·6	31·3	6·7
Serious suicide attempt	2·0	4·0	10·9	18·8	35·6	65·4	35·6	13·9
Linear trend (χ^2_1)	12·2***	12·4***	35·3***	91·7***	54·02***	97·30***	52·9***	21·40***

† Including immediate family members as well as more remote relatives (as defined by respondent).
*** $P < 0{\cdot}001$.

Table 3. *Individual and joint association of reported psychiatric disorders and: (i) persistent suicidal thoughts or any attempt or plan; (ii) serious suicide attempt*

	Association of individual disorders				Joint association			
	Persistent thoughts*		Serious attempt		Persistent thoughts*		Serious attempt	
	Adjusted OR†	95% CI	Adjusted OR†	95% CI	Partial OR†	95% CI	Partial OR†	95% CI
Major depressive episode(s) (DSM-IV)	7·45	6·26–8·86	9·62	6·42–14·41	5·83	4·82–7·04	6·05	3·88–9·44
Mania (non-diagnostic)‡	9·34	3·34–26·09	7·66	1·70–34·49‡	3·21^{NS}	1·00–10·30	0·78^{NS}	0·07–8·72
Panic disorder	5·67	4·15–7·74	8·47	4·95–14·50	3·08	2·18–4·34	3·96	2·31–6·81
Social phobia								
Women	4·62	3·03–7·02	15·58	8·01–30·31	1·84	1·10–3·06	f: 5·48	2·42–12·41
Men			1·43^{NS}	0·19–10·71§			—	—
Alcohol dependence								
Women	4·22	3·13–5·69	5·08	3·27–7·87	2·15	1·68–2·77	2·47	1·49–4·07
Men	2·97	2·17–4·06						
Childhood conduct problems								
Women	7·46	4·89–11·39	5·88	3·38–10·24	4·38	2·62–7·33	2·92	1·68–5·10
Men	2·92	2·13–4·00			2·36	1·65–3·37		

Diagnostic assessments are based on DSM-III-R criteria unless otherwise indicated; 95% confidence intervals for odds ratios are estimated by bootstrapping, unless otherwise indicated.
* Including cases reporting any suicide attempt or plan (PT/P/A).
† Controlling for birth cohort and gender.
‡ Based on clinician review of non-diagnostic screening questions for episodes of mania.
§ Unadjusted confidence interval. Adjusted confidence interval could not be estimated by bootstrapping because of small numbers.

haviour. Thus, individually, history of major depressive episodes, mania and panic disorder were all strongly associated both with reporting PT/P/A, and with making an SA, with no gender difference in the strength of the association. History of alcohol dependence, and of childhood conduct problems, were more strongly associated with PT/P/A in women than in men, but equally predictive of SA in both sexes. History of social phobia was equally predictive of PT/P/A in men and women, but was strongly associated with SA in women (OR = 15·6), but not significantly related to SA in men.

In the joint analysis, history of major depressive episodes emerged as the major determinant of suicidal thoughts and behaviour (OR = 5·8 for PT/P/A, 6·1 for SA), with history of panic disorder and (in women only) of social phobia also being important predictors of SA (ORs = 4·0, 5·5 respectively), and history of childhood conduct problems being a strong predictor of PT/P/A in women (OR = 4·4). History of mania was no longer a significant predictor – apparently its effects could be explained by associated major depressive episodes; and social phobia remained significantly predictive of SA only in women. Other disorders continued to have a significant and moderately strong association (OR of 2–3). Of note, the sex difference in the association between history of alcohol dependence and PT/P/A disappeared once the effects of other disorders were controlled for, implying that it was explained by comorbid psychopathology; but history of childhood conduct problems remained a more powerful predictor of PT/P/A in women than in men.

Traumatic events and stressors

Associations between lifetime traumatic events reported by women who also responded to the 1989 survey, and suicidal thoughts and behaviour, are summarized in Table 4. Also given in Table 4 are the associations, in men and women, of childhood sexual abuse and of divorce or separation at interview follow-up. Once again, the first four columns report overall associations between individual events and suicidality, controlling only for birth cohort; the next four columns report partial odds ratios once the effects of history of psychiatric disorder (i.e. those disorders included in Table 3) are controlled for. The most pronounced effects were observed for events involving rape or sexual abuse or physical assault ('assault' events); events involving property loss, job loss or loss of job status, and marital separation or divorce ('status loss' events), had an intermediate association with suicidality; and certain bereavement events (sudden death of a loved one; loss of a pregnancy) and serious accidents had only a weak association, while other traumatic events (loss of a child; life-threatening illness, infertility problems) had a non-significant association (not shown). Both assault events and status loss events showed a stronger association with reporting a suicide attempt than with the broader category of persistent suicidal thoughts. Both of these classes of event remained significantly predictive of PT/P/A and SA even when the respondent's history of psychopathology was controlled for, implying either an effect on course or severity of disorder, or an effect additional to that of any psychiatric history.

Sociodemographic and personality correlates

Controlling for birth cohort, and for those traumatic events or stressors assessed in both men and women, i.e. marital separation or divorce at the time of interview, and childhood history of sexual abuse, religious affiliation was the only significant sociodemographic correlate of suicidal thoughts and behaviour. Educational level, and religious involvement (frequency of church attendance) were not significant predictors. Individuals reporting a religious affiliation of 'none' were slightly more likely to report PT/P/A (OR = 1·46, 95% CI 1·16–1·86). SAs were reported much less often by Roman Catholics (OR = 0·34, 95% CI 0·20–0·76). Only the latter association remained significant when history of psychopathology was controlled for (OR = 1·34, 95% CI = 0·06–29·41; OR = 0·36, 95% CI = 0·17–0·76). In these same analyses, three personality measures assessed in 1980–81 were also significant correlates of persistent suicidal thoughts and of making a serious suicide attempt: Neuroticism (inter-quartile OR = 2·03, 1·80–2·29 for PT/P/A; OR = 2·60, 1·89–3·57 for SA); Toughmindedness (OR = 1·22, 1·06–1·40 for PT/P/A; OR = 1·40, 1·00–1·97 for SA); and Social Non-conformity (OR = 1·17, 1·07–1·26 for PT/P/A; OR = 1·25, 1·07–1·46 for SA). Once history of psychopathology was controlled

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Table 4. *Association of individual traumatic life events and: (i) persistent suicidal thoughts or any attempt or plan: (ii) serious suicide attempt*

	Controlling for birth cohort				Controlling also for psychiatric history			
	Persistent thoughts		Serious attempt		Persistent thoughts		Serious attempt	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Women only*								
Any rape/sexual assault*	3·63	2·69–4·91	7·57	4·46–12·85	2·21	1·58–3·09	3·42	1·82–6·42
Physical assault*	3·69	2·69–5·06	5·03	2·83–8·91	2·34	1·61–3·41	2·57	1·31–5·03†
Serious accident*	2·04	1·45–2·86	2·78	1·38–5·57	1·58	1·08–2·32	—	—
Broken marriage relationship*	3·00	2·39–3·78	4·35	2·68–7·05	2·21	1·71–2·85	2·93	1·69–5·09
Loss of job/job status*	2·83	2·18–3·68	3·77	2·27–6·25	2·06	1·54–2·75	2·47	1·41–4·33†
Sudden death of loved one*	1·35	1·09–1·66	—	—	—	—	—	—
Loss of pregnancy*	1·54	1·22–1·94	1·81	1·09–3·03	1·31	1·01–1·69	—	—
Property/home loss*	2·12	1·52–2·95	4·20	2·49–7·11	1·47	1·02–2·12	3·10	1·70–5·64
Women and men‡								
Childhood sexual abuse	3·79	2·84–5·07	7·43	4·66–11·84	2·07	1·47–2·91	3·11	1·74–5·57
Currently separated/divorced	2·38	1·92–2·95	3·52	2·32–5·34	1·51	1·19–1·91	2·19	1·36–3·53

Only significant odds ratio are shown; 95% confidence intervals for odds ratios are estimated by bootstrapping, unless otherwise indicated.
* Limited to female respondents who also responded to 1989 survey, since data were not obtained from other respondents.
† Unadjusted confidence interval. Adjusted confidence interval could not be estimated by bootstrapping because of small numbers.
‡ Analyses control also for gender.

Table 5. *Twin pair probandwise concordances (C) and polychoric correlations (ρ) and standard errors (S.E.) for suicidal thoughts and behaviour*

	MZ female ($N = 936$)			DZ female ($N = 540$)			MZ male ($N = 401$)			DZ male ($N = 235$)			DZ unlike-sex ($N = 604$)			
	C	ρ	S.E.	C	ρ	S.E.	C	ρ	S.E.	C	ρ	S.E.	C_M	C_F	ρ	S.E.
Any suicidal thoughts	0·44	0·49	0·05	0·26	0·10	0·08	0·41	0·42	0·08	0·31	0·17	0·12	0·34	0·32	0·17	0·08
Persistent thoughts/plan/minor attempt	0·27	0·40	0·07	0·21	0·26	0·10	0·35	0·56	0·09	0·15	0·09	0·18	0·17	0·17	0·16	0·11
Serious attempt	0·29	0·68	0·11	0	—*	—*	0·12	0·39	0·25	0	—*	—*	0	0	—*	—*
Severity of suicidal thoughts or behaviour	—	0·49	0·04	—	0·11	0·08	—	0·42	0·07	—	0·14	0·11	—	—	0·15	0·07

The probandwise concordance rate (C) is the probability that the cotwin of a suicidal twin (C_F, of the female twin from unlike-sex pairs; C_M, of the male twin) will also be suicidal.
* Correlation could not be estimated – no concordant pairs.

for, associations with Toughmindedness and Social Non-conformity were no longer significant, while the associations with Neuroticism were reduced (PT/P/A: OR = 1·60, 1·34–1·84; SA: OR = 1·78, 1·31–2·43).

Heritability of suicidality

Table 5 summarizes twin pair concordances and polychoric correlations for: (i) any suicidal thoughts; (ii) PT/P/A; (iii) SA; and (iv) the 4-point suicidal severity scale. Concordance rates, and tetrachoric correlations, were in all cases higher for MZ than for DZ pairs, consistent with an important genetic influence on suicidality. The risk of a serious suicide attempt in the co-twin, if an MZ twin had made a serious attempt, pooling across sexes, was 23·1%, a more than 10-fold increase in risk compared to the total sample. In contrast, there were no dizygotic pairs concordant for making serious suicide attempts.

Model-fitting analyses yielded point estimates of heritability (the proportion of the total variance in risk attributable to genetic effects) of 43% for the broad category of reporting any suicidal ideation, and 44% for reporting persistent suicidal thoughts or any suicide plan or attempt, with the hypothesis of no genetic influence rejected by likelihood-ratio χ^2 at a high level of statistical significance in each case ($\chi^2 = 23{\cdot}17$, df = 1, $P < 0{\cdot}001$; $\chi^2 = 8{\cdot}29$, df = 1, $P = 0{\cdot}004$). For serious suicide attempts, a point estimate of heritability of 55% was obtained, with the hypothesis of no genetic effects again rejected ($\chi^2 = 11{\cdot}22$, df = 1, $P < 0{\cdot}001$). In none of these analyses was a significantly elevated rate of suicidal thoughts or behaviour observed in twins whose co-twin did not respond to the survey ('singles'), compared to twins from complete pairs, implying that non-random sample attrition was not a significant problem. Because of the relative rarity of suicidal behaviour, particularly in its more serious manifestations, these individual estimates will be quite imprecise. Thus, when genetic models were fitted to the suicidal severity scale data, the estimated heritability of suicidality under an additive genetic model was 44% (47% under a model allowing for genetic dominance as well as additive genetic effects). The 95% CI for the heritability estimate was 33% to 51%. The confidence interval for the narrower measures of persistent thoughts or serious attempts would of course be still broader.

Social closeness and twin pair concordance

MZ pairs were much more likely to report almost daily social contact at interview follow-up (MZ female pairs 33·4%, DZ female like-sex pairs, 15·9%, $\chi^2 = 181{\cdot}90$, df = 1, $P < 0{\cdot}001$; MZ male pairs 16·1%, DZ male like-sex pairs 8·4%, $\chi^2 = 60{\cdot}07$, df = 1, $P < 0{\cdot}001$), raising the possibility that the apparent heritability of suicidal behaviour was in fact a social contagion effect. Age-of-onset information suggested that, while a social contagion effect for suicide attempts could not be ruled out in all cases, it could not entirely explain the higher MZ than DZ concordance for suicidal thoughts and behaviour. Out of nine pairs where both reported attempting suicide, only three reported ages at first attempted suicide that were nearly contemporaneous (2 MZ female pairs, 1 DZ female pair). In one MZ female pair the twin who made the later suicide attempt (age 22 *versus* age 21) apparently did not know that her twin sister had made an attempt, i.e. did not report that her co-twin had made any suicide attempts, suggesting that a contagion effect was not involved. In the DZ female pair, only one twin reported knowing about the other twin's attempt, but since both reported the same age at first attempt (22), we cannot exclude a social contagion effect; and in the third, MZ female pair (first attempts at ages 18, 19) each reported that the other had made an attempt, so that a social contagion effect clearly could not be ruled out. For the remaining six pairs, all but one of which were monozygotic, the interval between reported age at first suicide attempt ranged from 6 to 21 years, and in four of these six cases (all MZ) the twin who reported the later age at first attempt apparently did not know that the other twin had made a suicide attempt. While we cannot completely rule out the possibility, it seems unlikely that the later twin's suicide attempt was 'acquired' contagiously from the first twin, but that the later twin subsequently 'forgot' the first twin's attempt, while remembering their own attempt!

Synthesis

A genetic epidemiological perspective on suicidal thoughts and behaviour requires that we integrate the above findings on family history,

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Table 6. *Association of suicidal thoughts and behaviour with lifetime psychiatric history, personality and sociodemographic variables, traumatic events and family history (co-twin's suicidality)*

	Persistent thoughts/plan/attempt						Serious suicide attempt					
	Ignoring family history		Family history only		Joint analysis		Ignoring family history		Family history only		Joint analysis	
	Partial OR	95% CI	Partial OR	95% CI	Partial OR	95% CI	Partial OR	95% CI	Partial OR	95% CI	Partial OR	95% CI
Psychiatric												
Major depression	4·94	4·01–6·09			4·80	3·89–5·92	4·86	2·96–7·98			4·65	2·78–7·77
Panic disorder	2·35	1·62–3·42			2·26	1·53–3·33	2·59	1·29–5·20			2·38	1·17–4·85
Social phobia	—	—			—	—	f: 3·90	1·56–9·77			f: 3·25	1·33–7·92
							m: —	—			m: —	—
Alcohol dependence	1·79	1·40–2·30			1·74	1·35–2·23	1·77	1·06–2·95			1·72	1·02–2·92
Childhood conduct problems	f: 3·93 m: 2·35	2·31–6·71 1·68–3·29			f: 3·69 m: 2·29	2·13–6·38 1·64–3·20	2·53	1·41–4·55			2·37	1·27–4·42
Personality/ sociodemographic												
EPQ Neuroticism	1·64	1·42–1·90			1·58	1·36–1·83	1·99	1·42–2·79			1·88	1·33–2·65
Catholic	—	—			—	—	0·33	0·16–0·70			0·35	0·16–0·75
No religion	1·35	1·01–1·81			1·31^{NS}	0·98–1·75	—	—			—	—
Born pre-1930	0·46	0·28–0·77	0·35	0·22–0·57	0·50	0·30–0·80	—	—			—	—
Traumatic events/stressors												
Childhood sexual abuse	2·14	1·52–3·00			2·03	1·44–2·85	3·49	2·03–5·99			3·18	1·82–5·58
Divorce/marital separation	1·46	1·14–1·89			1·40	1·08–1·83	2·29	1·40–3·74			2·15	1·30–3·54
Co-twin's suicidality/family history												
MZ co-twin												
Serious attempt			8·48	4·49–16·03	3·74	1·73–8·08			17·53	6·14–50·01	3·79	1·04–13·82
Persistent thoughts/plan/ minor attempt			2·60	1·71–3·96	2·06	1·26–3·37			5·08	2·65–9·74	3·77	1·80–7·89
Any suicidal thoughts			1·77	1·26–2·50	1·55	1·04–2·31			1·90^{NS}	0·58–6·21	1·62^{NS}	0·47–5·59
No suicidal thoughts			0·61	0·49–0·77	0·71	0·55–0·90			0·54^{NS}	0·29–1·02	0·72^{NS}	0·37–1·40
DZ co-twin												
Serious attempt			2·21^{NS}	0·90–5·45	1·13^{NS}	0·42–3·05			—	—	—	—
Persistent thoughts/plan/ minor attempt			1·76	1·06–2·92	1·47^{NS}	0·83–2·59			3·22	1·43–7·27	2·37^{NS}	0·94–5·96
Any suicidal thoughts			1·13^{NS}	0·75–1·71	1·11^{NS}	0·70–1·76			—	—	—	—
No suicidal thoughts			1·00	—	1·00	—			1·00	—	1·00	—
Log-likelihood $-2\ln L$	2914·97		3432·56		2862·73		711·52		869·51		685·68	
Goodness-of-fit *v.* joint analysis												
df	7		9		—		5		9		—	
χ^2	52·24		574·70		—		24·84		183·83		—	
P	< 0·001		< 0·001		—		< 0·001		< 0·01		—	

95% CIs for ORs were estimated by bootstrapping.

psychopathology, personality, traumatic event and sociodemographic correlates of suicidal thoughts and behaviour. Table 6 presents such a synthesis. For the two outcome measures – PT/P/A and SA – three sets of columns are shown, presenting the results of analyses which: (*a*) use all information except family history; (*b*) use only family history information plus birth cohort; and (*c*) use all available information. The log-likelihood of the data for each analysis is also reported, together with likelihood-ratio χ^2 values comparing the joint analysis with the other two analyses. For family history data, consideration is limited to co-twin's history of suicidal thoughts, since the interpretation of such data is no longer straightforward when parental as well as co-twin information is included in the analyses.

We consider first the results of analyses predicting persistent suicidal thoughts. Both the model ignoring family history, and the model limited to family history plus age cohort variables, gave significantly worse fits than the more general model: neither set of variables could be ignored. Compared with the analysis ignoring family history, however, controlling for co-twin's suicidality had only a modest impact on estimates of the associations of persistent suicidal thoughts with psychiatric, personality/demographic and traumatic event measures. The estimated OR for Neuroticism in males was somewhat reduced, but otherwise parameter estimates were essentially unchanged. In contrast, associations with family history were substantially reduced once these latter variables were controlled for. Nonetheless, a significant association with co-twin's history, that was at least in part genetically mediated, remained: there were significant associations with MZ co-twin's history of suicide attempts, persistent thoughts, or any suicidal thoughts, and having an MZ co-twin with no history of suicidal thoughts was significantly protective. In contrast, DZ co-twin's history was not significantly predictive of risk of persistent suicidal thoughts, once psychiatric, personality, sociodemographic and traumatic event covariates were controlled for.

An essentially similar pattern was seen in the case of serious suicide attempts. Estimates of the association between psychiatric, sociodemographic/personality and traumatic event variables and serious suicide attempts varied little between analyses with and without co-twin's suicidality variables; but inclusion of the latter still led to a significant improvement in prediction. In particular, a history of one or more serious suicide attempts or persistent thoughts or plan or minor attempt reported by an MZ co-twin remained significantly associated with probability of reporting a serious suicide attempt.

DISCUSSION

The assessment of lifetime history of suicidal behaviour used in the telephone interview survey of the Australian twin panel was a free-standing interview module that was not linked by context to questions about history of depression or other specific psychopathology. Interviewees were drawn from a volunteer community-based sample that was unselected with regard to clinical history, avoiding the potential confounds associated with Berkson's bias. Because both MZ and DZ twin pairs were surveyed, the sample was informative about genetic as well as environmental influences on risk. To our knowledge, this represents the first such large-scale study to combine epidemiological and genetic perspectives on suicidality.

Several findings emerged from our analysis of the epidemiology and genetics of suicidal thoughts and behaviour in this sample: the eight main points are as follows.

Absence of any sex difference in lifetime rates of suicidal thoughts and behaviour

Despite pronounced sex differences in the lifetime prevalence of major depression, alcohol dependence, and childhood conduct disorder – disorders that are strongly predictive of suicidal thoughts and behaviour – significant sex differences in rates of suicidal thoughts and behaviour were observed only for a single measure, suicide attempts, which were more commonly reported by women than by men.

Similar rates of suicidal thoughts and behaviour were reported by birth cohorts born between 1930–1964

As in the case of sex differences, significant cohort differences in lifetime prevalence of major depression, alcohol dependence and childhood

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conduct disorder did not lead to significant cohort differences in rates of PT/P/A (persistent suicidal thoughts or any suicide plan or attempt) or SA (serious attempt). Only in the oldest cohort, born prior to 1930, was reduced reporting of suicidality observed. Apparently, in this sample, the increasing incidence in recent years of suicidal thoughts and behaviour represents a period effect that is affecting most cohorts, although we cannot exclude increased forgetfulness or denial in the oldest cohort.

Importance of familial (including genetic) influences on suicidal thoughts and behaviour

Having an identical twin who had made a serious suicide attempt was associated with a 10-fold increase in risk of making such an attempt, a significantly stronger association than that observed in the case of fraternal twin pairs. Genetic model-fitting yielded a heritability of suicidality of approximately 45%. It does not appear that social contagion effects can entirely explain the higher concordance of MZ than DZ pairs for suicidal thoughts and behaviour. Out of nine pairs concordant for suicide attempts, there were only two cases where a contagion effect was plausible (one MZ, one DZ) and two cases where a contagion effect seemed unlikely but could not be completely ruled out (one MZ, one DZ). High levels of social closeness (e.g. almost daily social contact) were observed between fraternal as well as identical twin sisters, and generally equally high rates of social closeness between fraternal twin sisters and identical twin brothers.

Associations of psychiatric history and trait Neuroticism with suicidal thoughts and behaviour

While history of major depression was the most powerful predictor, history of conduct disorder, history of alcohol dependence, and history of panic disorder were all associated with further increases in risk of PT/P/A, and with the exception of alcohol dependence (which fell just short of statistical significance), and of childhood conduct disorder in women, these same variables also predicted increased risk of SA. History of social phobia was a very powerful predictor of SA in women, even when other psychopathology was controlled for. Neuroticism, assessed in the 1981 survey, remained a significant predictor when psychiatric history was controlled for.

Associations of traumatic events/stressors with suicidal thoughts and behaviour

For women in the sample who responded to the 1989 traumatic events/stressors questions, assault events (rape or physical assault) and to a lesser degree status-loss events (broken marriage, loss of job or of job status, property or home loss), but not bereavement events (death of loved one, pregnancy loss), were associated with an increased risk of PT/P/A and of SA. In both sexes, a reported episode of sexual abuse in childhood was associated with substantially increased risk of SA, even when psychiatric history and co-twin's history of suicidality were controlled for (OR = 3·6), and current marital separation or divorce was also associated with an increased risk (OR = 2·0).

Sociodemographic predictors

Individuals who reported a religious affiliation of Roman Catholic (which is associated with a prohibition against suicide) were indeed less likely to report a serious suicide attempt, but no less likely to report PT/P/A. Other sociodemographic variables were not predictive of differences in suicidal behaviour, once history of psychopathology and traumatic events were controlled for.

Relative influence of psychiatric and psychosocial variables and familial suicidality

Psychiatric history, experience of traumatic events, and personality and sociodemographic variables, jointly, were more powerful predictors of suicidal thoughts and behaviour than was familial history of suicidality. In a joint analysis (Table 6), personal history of depression was a more powerful predictor of PT/P/A and of SA than having an MZ co-twin who had made a serious suicide attempt (albeit not significantly so). In the case of making a serious suicide attempt, a history of childhood sexual abuse was also almost as strong a predictor.

Genetic influences are only partially explained by axis I disorders and personality

Controlling for psychiatric history and for other psychosocial variables, MZ co-twin's history of suicidal thoughts and behaviour remained a

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powerful predictor of increased risk of PT/P/A and of SA. Controlling for other variables, the ORs for the association between respondent's report of SA, and history of SA or PT/P/A in the MZ co-twin, were in each case approximately 4. (In contrast, only one aspect of DZ co-twin's suicidal behaviour was predictive (PT/P/A) and for only a single outcome variable (SA).) Thus it appears that there is significant familial (and most probably genetic) variance in suicidality that is not accounted for by measured psychiatric, personality and sociodemographic variables. While the diagnostic interview used in the survey was by no means comprehensive, the low base-rate of disorders that were not assessed makes it unlikely that these would have accounted for much of the residual genetic variance. It seems more likely that there is a specific genetic vulnerability to suicidal thoughts and behaviour, an issue that will be addressed further in the future.

In interpreting the results of these analyses, several important limitations need to be borne in mind. The interview survey from which these data were gathered was not designed with the assessment of suicidal thoughts and behaviour as a primary goal. As a consequence, no detailed histories were taken of the dates when periods of suicidal thoughts or attempts occurred, so that no temporal sequencing of events is possible. The traumatic events assessment did not obtain information about timing of events. The survey was necessarily limited to gathering information about suicidal thoughts and attempts – the lifetime rate of completed suicide (two known cases) would be too low for these analyses to be informative about this topic.

There of course remain further questions that may be posed about the interplay of genetic and environmental influences, which are beyond the scope of the present manuscript. Results of the analyses presented here nonetheless provide a powerful illustration of how psychiatric history, personality, genetic vulnerability, traumatic events, and at least one major sociocultural protective factor (Roman Catholic religious affiliation) combine to predict suicidal thoughts and attempts. Ignoring either the genetic perspective (by failing to use a family study design) or the importance of environmental determinants of suicidal behaviour (by limiting analyses to conventional assessments of heritability of suicidality) would have failed to capture this complexity.

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REFERENCES

Allebeck, P., Allgulander, C. & Fisher, L. D. (1988). Predictors of completed suicide in a cohort of 50465 young men: role of personality and deviant behaviour. *British Medical Journal* **297**, 176–178.

American Psychiatric Association (1987). *Diagnostic and Statistical Manual of Mental Disorders, 3rd edn* (*Revised*). American Psychiatric Association: Washington, DC.

Apter, A., Gothelf, D., Orbach, I., Weizman, R., Ratzoni, G., Har-Even, D. & Tyano, S. (1995). Correlation of suicidal and violent behavior in different diagnostic categories in hospitalized adolescent patients. *Journal of the American Academy of Child and Adolescent Psychiatry* **34**, 912–918.

Asgard, U. (1990). A psychiatric study of suicide among urban Swedish women. *Acta Psychiatrica Scandinavica* **82**, 115–124.

Baker, L. A., Treloar, S. A., Reynolds, C. A., Heath, A. C. & Martin, N. G. (1996). Genetics of educational attainment in Australian twins: sex differences and secular changes. *Behavior Genetics* **26**, 89–102.

Beautrais, A. L., Joyce, P. R., Mulder, R. T., Fergusson, D. M., Deavoll, B. J. & Nightingale, S. K. (1996). Prevalence and comorbidity of mental disorders in persons making serious suicide attempts: a case-control study. *American Journal of Psychiatry* **153**, 1009–1014.

Bierut, L. J., Heath, A. C., Bucholz, K. K., Dinwiddie, S. H., Madden, P. A. F., Statham, D. J., Dunne, M. P. & Martin, N. G. (1998). Major depressive disorder: different genetic and environmental contributions for men and women. (Submitted.)

Brent, D. A., Perper, J. A., Moritz, G., Allman, C., Friend, A., Roth, C., Schweers, J., Balach, L. & Baugher, M. (1993). Psychiatric risk factors for adolescent suicide: a case–control study. *Journal of the American Academy of Child and Adolescent Psychiatry* **32**, 521–529.

Brent, D. A., Bridge, J. & Connolly, M. A. (1996). Suicidal behavior runs in families: a controlled family study of adolescent suicide victims. *Archives of General Psychiatry* **53**, 1145–1152.

Bucholz, K. K., Cloninger, C. R., Dinwiddie, S. H., Hesselbrock, V. M., Nurnberger, J. L., Reich, T., Schmidt, I. & Schuckit, M. A. (1994). A new, semi-structured psychiatric interview for use in genetic linkage studies: a report of the reliability of the SSAGA. *Journal of Studies on Alcohol* **55**, 149–158.

Caspi, A., Moffitt, T. E., Newman, D. L. & Silva, P. A. (1996). Behavioral observations at age 3 years predict adult psychiatric disorders. *Archives of General Psychiatry* **53**, 1033–1039.

Cheng, A. T. A. (1995). Mental illness and suicide: a case-control study in East Taiwan. *Archives General Psychiatry* **52**, 594–603.

https://doi.org/10.1017/S0033291798006916 Published online by Cambridge University Press

Gongalton, A. A. (1963). *Occupational Status in Australia*. University of New South Wales: Sydney.
Cornelius, J. R., Salloum, I. M., Day, N. L., Thase, M. E. & Mann, J. J. (1996). Patterns of suicidality and alcohol use in alcoholics with major depression. *Alcoholism: Clinical and Experimental Research* **20**, 1451–1455.
Cox, B. J., Direnfeld, D. M., Swinson, R. P. & Norton, G. R. (1994). Suicidal ideation and suicide attempts in panic disorder and social phobia. *American Journal of Psychiatry* **151**, 882–887.
Cross, C. K. & Hirschfield, R. M. A. (1986). Psychosocial factors and suicidal behavior. In *Psychobiology of Suicidal Behavior* (ed. J. J. Mann and M. Stanley), pp. 77–89. New York Academy of Sciences: New York.
Davidson, J. R., Hughes, D. C., George, L. K. & Blazer, D. G. (1996). The association of sexual assault and attempted suicide within the community. *Archives of General Psychiatry* **53**, 550–555.
Diekstra, R. F. (1989). Suicide and the attempted suicide: an international perspective. *Acta Psychiatrica Scandinavica* **80** (suppl. 354), 1–24.
Diekstra, R. F. W. & Gulbinat, W. (1993). The epidemiology of suicidal behaviour: a review of three continents. *World Health Statistical Quarterly* **46**, 52–68.
Duffy, D. L. (1994). Asthma and Allergic Diseases in Australian Twins and their families. Ph.D. thesis, University of Queensland.
Dyck, M. J. (1991). Positive and negative attitudes mediating suicide ideation. *Suicide and Life-Threatening Behavior* **21**, 360–373.
Eaves, L. J., Last, K. A., Young, P. A. & Martin, N. G. (1978). Model-fitting approaches to the analysis of human behavior. *Heredity* **41**, 249–320.
Eaves, L. J., Eysenck, H. J. & Martin, N. G. (1989). *Genes, Culture and Personality: An Empirical Approach*. Academic Press: London.
Efron, B. & Tibshirani, R. (1986). Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. *Statistical Science* **1**, 54–77.
Egeland, J. A. & Sussex, J. N. (1985). Suicide and family loading for affective disorders. *Journal of the American Medical Association* **254**, 915–918.
Eysenck, H. J. & Eysenck, S. B. G. (1975). *Manual of the Eysenck Personality Questionnaire*. Hodder & Stoughton: London.
Florequin, C., Hardy, P., Messiah, A., Ellrodt, A. & Feline, A. (1995). Suicide attempts and panic disorder: a study of 62 hospitalized suicidal patients. *Encephale* **21**, 87–92.
Gould, D. A., Stevens, N. G., Ward, N. G., Carlin, A. S., Sowell, H. E. & Gustafson, B. (1994). Self-reported childhood abuse in an adult population in a primary care setting. Prevalence, correlates, and associated suicide attempts. *Archives of Family Medicine* **3**, 252–256.
Heath, A. C., Cloninger, C. R. & Martin, N. G. (1994). Testing a model for the genetic structure of personality: a comparison of the personality systems of Cloninger and Eysenck. *Journal of Personality and Social Psychology* **66**, 762–775.
Heath, A. C., Madden, P. A. F., Slutske, W. S. & Martin, N. G. (1995). Personality and the inheritance of smoking behavior: a genetic perspective. *Behaviour Genetics* **25**, 103–117.
Heath, A. C., Bucholz, K. K., Madden, P. A. F., Dinwiddie, S. H., Slutske, W. S., Bierut, L. J., Statham, D. J., Dunne, M. P., Whitfield, J. & Martin, N. G. (1997). Genetic and environmental contributions to alcohol dependence risk in a national twin sample: consistency of findings in women and men. *Psychological Medicine* **27**, 1381–1396.
Henriksson, M. M., Aro, H. M., Marttunen, M. J., Heikkinen, M. E., Isometsa, E. T., Kuoppasalmi, K. I. & Lonnqvist, J. K. (1993). Mental disorders and comorbidity in suicide. *American Journal of Psychiatry* **150**, 935–940.
Hirschfeld, R. M. (1996). Panic disorder: diagnosis, epidemiology, and clinical course. *Journal of Clinical Psychiatry* **57** (suppl. 10), 3–8.
Irfani, S. (1978). Personality correlates of suicidal tendency among Iranian and Turkish students. *Journal of Psychology* **99**, 151–153.
Jardine, R. & Martin, N. G. (1984). Causes of variation in drinking habits in a large twin sample. *Acta Geneticae Medicae et Gemellologiae* **33**, 435–450.
Jardine, R., Martin, N. G. & Henderson, A. S. (1984). Genetic covariation between neuroticism and the symptoms of anxiety and depression. *Genetic Epidemiology* **1**, 89–107.
Juel-Nielsen, N. & Videbech, Th. (1970). A twin study of suicide. *Acta Geneticae Medical et Gemellologiae* **19**, 307–310.
Kallmann, F. (1953). *Heredity in Health and Mental Disorder*. W. W. Norton: New York.
Kendler, K. S., Heath, A. C., Martin, N. G. & Eaves, L. J. (1986). Symptoms of anxiety and depression in a volunteer twin population: The etiologic role of genetic and environmental factors. *Archives of General Psychiatry* **43**, 213–221.
Kendler, K. S., Neale, M. C., Kessler, R. C., Heath, A. C. & Eaves, L. J. (1993). A longitudinal twin study of personality and major depression in women. *Archives of General Psychiatry* **50**, 853–862.
Kendler, K. S., Kessler, R. C., Walters, E. E., MacLean, C., Neale, M. C., Heath, A. C. & Eaves, L. J. (1995*a*). Stressful life events, genetic liability and episode onset of major depression in women: evidence for genetic control of sensitivity to the environment. *American Journal of Psychiatry* **152**, 833–842.
Kendler, K. S., Walters, E. E., Neale, M. C., Kessler, R. C., Heath, A. C. & Eaves, L. J. (1995*b*). The structure of the genetic and environmental risk factors for six major psychiatric disorders in women: phobia, generalized anxiety disorder, panic disorder, bulimia, major depression and alcoholism. *Archives of General Psychiatry* **52**, 374–383.
Lepine, J. P., Chignon, J. M. & Teherani, M. (1993). Suicide attempts in patients with panic disorder. *Archives of General Psychiatry* **50**, 144–149.
Lester, D. (1986). Genetics, twin studies, and suicide. Special Issue: Suicide and life-threatening behavior. *Suicide and Life-Threatening Behavior* **16**, 274–285.
Lish, J. D., Zimmerman, M., Farber, N. J., Lush, D. T., Kazuma, M. A. & Plescia, G. (1996). Suicide screening in a primary care setting at a Veterans Affairs Medical Center. *Psychosomatics* **37**, 413–424.
Martin, N. G., Perl, J., Oakeshot, J. G., Gibson, J. B., Starmer, G. A. & Wilks, A. V. (1985*a*). A twin study of ethanol metabolism. *Behavior Genetics* **15**, 93–109.
Martin, N. G., Oakeshott, J. G., Gibson, J. B., Starmer, G. A., Perl, J. & Wilks, A. V. (1985*b*). A twin study of psychomotor and physiological responses to an acute dose of alcohol. *Behavior Genetics* **15**, 305–347.
Moscicki, E. K. (1989). Epidemiologic surveys as tools for studying suicidal behavior: a review. *Suicide and Life-Threatening Behavior* **19**, 131–146.
Murphy, G. E. & Wetzel, R. D. (1982). Family history of suicidal behavior among suicide attempters. *Journal of Nervous and Mental Disease* **170**, 86–90.
Murphy, G. E. & Wetzel, R. D. (1990). The lifetime risk of suicide in alcoholism. *Archives of General Psychiatry* **47**, 383–392.
Murphy, G. E., Wetzel, R. D., Swallow, C. S. & McClure, J. N. (1969). Who calls the Suicide Prevention Centre: a study of 55 persons calling on their own behalf. *American Journal of Psychiatry* **126**, 314–324.
Murphy, G. E., Wetzel, R. D., Robins, E. & McEvoy, L. (1992). Multiple risk factors predict suicide in alcoholism. *Archives of General Psychiatry* **49**, 459–463.
Neale, M. C. (1997). *MX: Statistical Modeling*. Department of Psychiatry, Virginia Commonwealth University: Richmond, VA.
Neale, M. C. & Miller, M. B. (1997). The use of likelihood-based confidence intervals in genetic models. *Behavior Genetics* **27**, 113–120.
Nordstrom, P., Schalling, D. & Asberg, M. (1995). Temperamental vulnerability in attempted suicide. *Acta Psychiatrica Scandinavica* **92**, 155–160.
Paykel, E. S., Myers, J. K., Lindenthal, J. J. & Tanner, J. (1974). Suicidal feelings in the general population: a prevalence study. *British Journal of Psychiatry* **124**, 460–469.
Petronis, K. K., Samuels, J. F., Moscicki, E. K. & Anthony, J. C.

https://doi.org/10.1017/S0033291798006916 Published online by Cambridge University Press

(1990). An epidemiologic investigation of potential risk factors for suicide attempts. *Social Psychiatry and Psychiatric Epidemiology* **25**, 193–199.

Robins, E., Schmidt, E. H. & O'Neal, P. (1957). Some interrelations of social factors and clinical diagnosis in attempted suicide: a study of 109 patients. *American Journal of Psychiatry* **114**, 221–231.

Roy, A. (1983). Family history of suicide. *Archives of General Psychiatry* **40**, 971–974.

Roy, A. (1985). Suicide and psychiatric patients. *Psychiatric Clinics of North America* **8**, 227–241.

Roy, A. (1988). Are there genetic factors in suicide? *Canadian Journal Psychiatry* **33**, 79–80.

Roy, A., Lamparski, D., DeJong, J., Moore, V. & Linnoila, M. (1990). Characteristics of alcoholics who attempt suicide. *American Journal of Psychiatry* **147**, 761–765.

Roy, A., Segal, N. L., Centerwall, B. S. & Robinette, C. D. (1991). Suicide in twins. *Archives of General Psychiatry* **48**, 29–32.

Roy, A., Segal, N. L. & Sarchiapone, M. (1995). Attempted suicide among living co-twins of twin suicide victims. *American Journal of Psychiatry* **152**, 1075–1076.

Schulsinger, F., Kety, S. S., Rosenthal, D. & Wender, P. H. (1979). A family study of suicide. In *Origin, Prevention and Treatment of Affective Disorders* (ed. M. Schou and E. Stomgren), pp. 277–287. Academic Press: London.

Schwab, J. J., Warheit, G. J. & Holzer, C. E. (1972). Suicidal ideation and behavior in a general population. *Diseases of the Nervous System* **33**, 745–748.

Smith, J. C., Mercy, J. A. & Conn, J. M. (1988). Marital status and the risk of suicide. *American Journal of Public Health* **78**, 78–80.

Tsuang, M. T. (1983). Suicide in the relatives of schizophrenics, manics, depressives, and controls. *Journal Clinical Psychiatry* **44**, 396–400.

Weissman, M. M., Klerman, G. L., Markowitz, J. S. & Ouellette, R. (1989). Suicidal ideation and suicide attempts in panic disorder and panic attacks. *New England Journal of Medicine* **321**, 1209–1214.

Wender, P. H., Kety, S. S., Rosenthal, D., Schulsinger, F., Ortmann, J. & Lunde, I. (1986). Psychiatric disorders in the biological and adoptive families of adopted individuals with affective disorders. *Archives of General Psychiatry* **42**, 923–929.

Whitters, A. C., Cadoret, R. J., Troughton, E. & Widmer, R. B. (1987). Suicide attempts in antisocial alcoholics. *Nervous and Mental Diseases* **175**, 624–626.

Young, S. E., Mikulich, S. K., Goodwin, M. B., Hardy, J., Martin, C. L., Zoccolillo, M. S. & Crowley, T. J. (1995). Treated delinquent boys' substance use: onset, pattern, relationship to conduct and mood disorders. *Drug and Alcohol Dependence* **37**, 149–162.

https://doi.org/10.1017/S0033291798006916 Published online by Cambridge University Press