

The assessment of alcoholism in surveys of the general community: what are we measuring? Some insights from the Australian twin panel interview survey

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Summary

The majority of cases identified by commonly used alcoholism criteria in general community surveys are mild ones, with few alcohol-related problems. We illustrate this using data on 2088 Australian male twins aged 28–89 (mean age = 42.7), including 1846 who reported more than minimal alcohol exposure when surveyed by telephone in 1992–3. Using latent class analysis of alcoholism symptoms reported by these twins, we identify five classes of respondent: those with no alcohol-related problems (49% of the sample, if we include those with minimal alcohol exposure); excessive drinkers (33%); and individuals with a history of mild (14%), moderate (3%) or severe problems (1%). Symptom endorsement profiles associated with these different classes are illustrated. The two most severe classes constitute a substantial majority of those reporting alcoholism treatment, but a minority of those reporting alcohol-related auto accidents or injuries, recurrent hazardous alcohol use, or alcohol-related arrests. The excessive drinkers and persons with mild problems account for a much higher proportion of persons experiencing these outcomes, and thus represent an important group to study from a public health perspective. The use of latent class analysis to improve case detection using structured or semi-structured diagnostic instruments is also discussed.

Introduction

Comparatively high lifetime prevalence figures reported for psychiatric disorders such as alcoholism on the basis of general community surveys (e.g. ECA: Robins & Regier, 1991; National Comorbidity Survey: Kessler *et al.*, 1994) have not infrequently been viewed with scepticism by psychiatrists and other clinicians. Surveys of general community

samples for genetic research, such as those using the classical twin design (Kendler *et al.*, 1992, 1994; Kendler, 1993), which find a similarly high prevalence, receive a similar reaction. The bewilderment of clinicians undoubtedly is exacerbated by the failure of researchers to communicate the range of symptomatology that is observed in community samples, in which a majority of cases are typically

mild in form and unlikely to present for care in either inpatient or outpatient settings.

In this paper we re-examine the question of what we can discover from surveys of general community samples, using alcoholism data from the 1992–3 telephone interview survey of the Australian twin panel. We use the method of latent class analysis (McCutcheon, 1987) in an attempt to identify homogeneous groups of respondents having similar symptom endorsement profiles (e.g. subtypes of alcoholics), and to estimate their prevalence in the sample. Although latent class analysis as a statistical technique was developed many years ago (Goodman, 1974) applications in medicine (Rindskopf & Rindskopf, 1986; Walter *et al.*, 1991; Walter & Irwig, 1988) and in psychiatry (Young, 1982–3; Eaton *et al.*, 1989; Faraone & Tsuang, 1994; Kendler *et al.*, in review) have been a relatively recent phenomenon. Latent class analysis has been used (i) to estimate sensitivity and specificity of diagnostic assessments, allowing for measurement error and the absence of a 'gold-standard' (Rindskopf & Rindskopf, 1986; Walter *et al.*, 1991; Faraone & Tsuang, 1994); (ii) to subtype or identify as true cases individuals with psychiatric disorder identified from patient series (schizophrenia or other psychosis: Castle *et al.*, 1994; Lenzewheger & Dworkin, 1991; major depression: Parker *et al.*, 1990, 1993; Grove *et al.*, 1987) or from general community samples (e.g. delinquency or conduct problems: Fergusson *et al.*, 1993; major depression: Eaton *et al.*, 1989; Kendler *et al.*, in review); (iii) to assess degree of diagnostic agreement between raters (Uebersax & Grove, 1990) and to combine information from multiple informants into a single diagnostic classification (Fergusson *et al.*, 1993); (iv) to analyze longitudinal data to assess changes in a latent variable that is imperfectly measured ('latent transition analysis': Collins, 1991; Graham *et al.*, 1991); (v) and to better operationalize the heritable phenotype for psychiatric genetic research (Eaves *et al.*, 1993).

Methods

Sample

The Australian National Health and Medical Research Council (NH&MRC) twin panel, a volunteer panel of adult Australian twins, has been used extensively for alcohol-related research. In 1978–9 an alcohol challenge study involving some 206 twin pairs, unselected with regard to personal or family history of alcoholism, was undertaken, in order to

assess the genetic contribution to differences in self-report intoxication and deterioration in psychomotor performance after a body-weight adjusted challenge dose of alcohol (Martin *et al.*, 1985a, b; Heath & Martin, 1991). In 1980–81 a self-report questionnaire ('1981 survey') that included assessments of personality, alcohol consumption patterns, smoking and other health-related habits (but not alcohol-related problems) was mailed to 5967 twin pairs aged 17 and older registered with the twin panel at that period ('1981 cohort': Jardine & Martin, 1984; Heath *et al.*, 1991a, b), including 195 pairs from the alcohol challenge sample, with completed questionnaires being returned by both members of 64% of the twin pairs ($n = 3808$ pairs), and by one twin only from an additional 567 pairs (67% overall individual response rate). Alcohol consumption patterns reported by the twins in this survey did not deviate substantially from those reported for the general population of Australia based on a survey by the Australian Bureau of Statistics (Jardine & Martin, 1984). An eight-year follow-up survey of the 1981 cohort, that included assessments of both alcohol consumption patterns and problems, was conducted by mailed questionnaire in 1988–9 ('1989 cohort'), with mailings targeted at the complete pairs who had responded in 1981 (Heath & Martin, 1994; Heath, Cloninger & Martin, 1994). Data were obtained from both members of 79% of pairs ($n = 2997$ pairs), and by an additional 335 single twins (83% individual response rate). Finally in 1992–3 a telephone interview was conducted with (i) twin pairs where at least one twin had responded to the 1989 survey, and (ii) additional pairs who had not returned the 1989 survey but had participated in the original alcohol challenge survey (Heath *et al.*, in press). Adapted from the SSAGA, a diagnostic instrument developed for genetic research on alcoholism (Bucholz *et al.*, 1993), the interview provided diagnostic assessments of DSM-III-R alcohol dependence and other major axis I disorders (APA, 1987). Data were obtained from 5995 twins, including 89% of respondents who had responded to the 1989 survey, and 77% of the respondents from complete pairs who responded in the 1981 survey. The data presented in this paper are based on interviews completed with 2088 male respondents.

Measure

The SSAGA was designed to provide polydiagnostic assessments of alcohol dependence, including

Feighner, DSM-III-R and best-estimate projections of DSM-IV and ICD-10 criteria (Bucholz *et al.*, 1994). For the purposes of the Australian study, however, it was shortened and adapted to cover only DSM-III-R. Individuals who reported that they had never consumed more than three standard drinks in a 24-hour period, or who had never used alcohol as often as once a month for a period of at least six months, and had never been intoxicated, were not asked questions about alcohol-related problems. We refer to these individuals as having 'minimal alcohol exposure'.

Data-analysis

Latent class models (see McCutcheon, 1987, for an introductory account) were fitted to the alcoholism symptom data by the method of maximum likelihood, using a programme written by one of us (LJE; Eaves *et al.*, 1993). Other software available for latent class analysis (e.g. Clogg, 1977) has typically been designed for problems involving small numbers of items, and often will not handle contingent items that are asked only of a subset of subjects who have given a particular answer to another item. Structured diagnostic interviews, in contrast, typically involve many items, including many contingent items. Before use, the program was tested against a standard software package for latent class analysis (MLLSA; Clogg, 1977), using data-sets with small numbers of variables, and found to give the same results.

Latent class analysis is a form of categorical data-analysis which hypothesizes that it is possible to account for the observed symptom (or item) endorsement profiles of respondents in terms of some small number of mutually exclusive respondent classes (m), with each class having its own set of symptom endorsement probabilities. A critical assumption, that of 'local independence' (McCutcheon, 1987), is that under an m -class solution, the conditional probabilities of endorsing a set of items are statistically independent for a given class. Under a one-class model which does not distinguish even between alcoholics and non-alcoholics, this assumption is clearly false: an individual who reports a history of alcohol withdrawal symptoms is much more likely to report other alcoholism symptoms than one who does not. Under a two-class model, too, this assumption is almost as implausible, since even among those reporting any alcohol problems those reporting withdrawal symptoms are more likely to be included among the severe cases,

and to report also other more severe symptoms. However, as the number of latent classes estimated increases, it is assumed that homogeneous classes or types will be defined, such that individuals within a class will differ in symptom endorsement profile only because of measurement error or stochastic factors. Parameter estimates are (i) class membership probabilities (which in our application will be equivalent to lifetime prevalence estimates for the latent classes), and (ii) symptom endorsement probabilities for each class.

Latent class models were fitted by the method of maximum-likelihood, with class membership probabilities and item endorsement probabilities constrained to be equal in monozygotic and dizygotic twins (since there is no *a priori* reason why having an MZ or DZ cotwin should affect an individual's symptom endorsement profile). The goodness-of-fit of models estimating m and $m - 1$ classes was compared by likelihood-ratio chi-square test, with $(p + 1)$ degrees of freedom, where p is the number of items analysed (38 in the present application). As used here, all latent class models were fitted under the hypothesis of no family resemblance, implying that the non-independence of observations on twins from the same twin pair was ignored. In practice this assumption is not supported by the data. Nonetheless, this random environment model represents a baseline against which models allowing for twin pair concordance for class membership may be tested (Eaves *et al.*, 1993). Under latent class models allowing for familial resemblance, there is a possibility that patterns of symptom aggregation in families will influence the estimates of item endorsement probabilities for each class. We therefore focus on results under the random environment model, which can be compared directly to results obtained from epidemiologic surveys of samples of unrelated individuals.

Results

As is to be expected in a community survey, there is a substantial minority of respondents to the Australian twin panel interview survey with minimal exposure to alcohol. Figure 1 summarizes in the form of an (inverted) probability tree the proportions of males who have never used any alcohol (2%); who have never used alcohol regularly (i.e. at least once a month for at least six consecutive months) and never been drunk ($0.98 \times 0.08 \times 0.64 = 5\%$); and, among those who have used alcohol regularly or been intoxicated at least once,

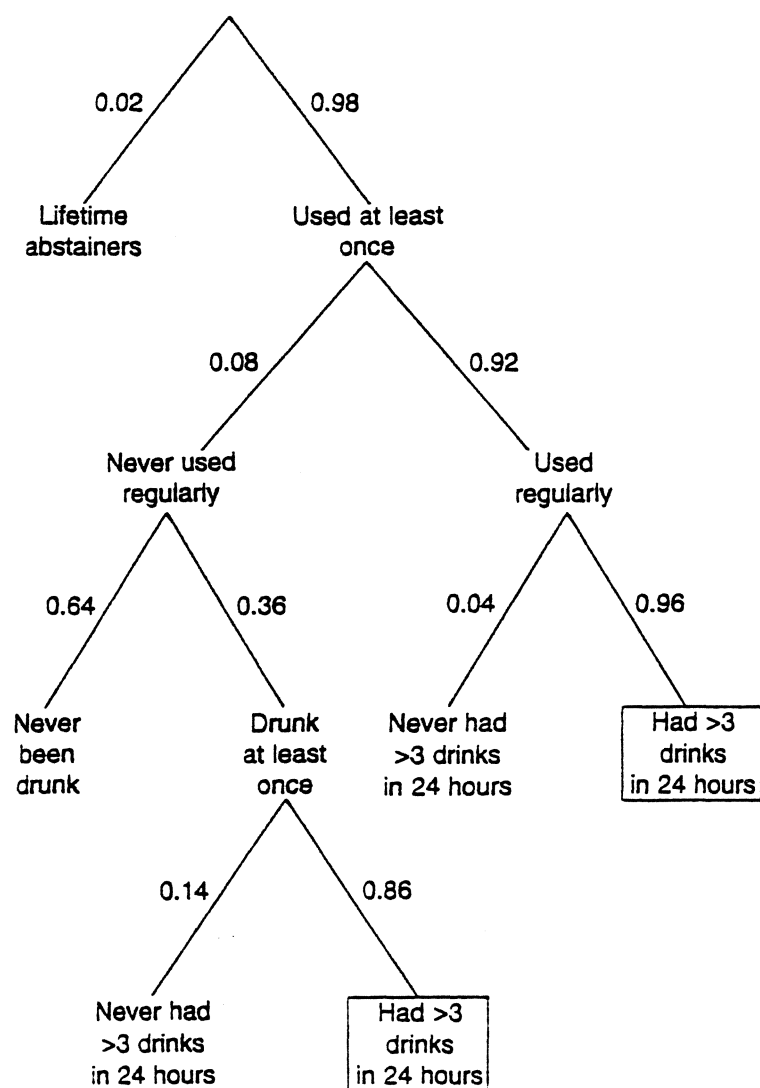


Figure 1. Inverted probability tree representation of the proportions of the sample who were either asked questions about their alcohol-related problems, or who were identified as having minimal alcohol exposure. Probabilities at the top of the tree are unconditional probabilities; those at lower levels are conditional probabilities, given the outcome at the next highest branch. Thus 2% of the sample are lifetime abstainers; 92% of non-abstainers have used alcohol regularly; 96% of those who have used alcohol regularly have had more than 3 standard drinks in a 24-hour period.

who have never had four or more drinks within a 24-hour period ($0.98 \times (0.92 \times 0.04 + 0.08 \times 0.36 \times 0.14) = 4\%$). These individuals, who comprised 11% of the total sample, were not asked questions about alcohol-related problems, and were excluded from further analyses reported in this paper. The definition of minimal exposure to alcohol that we have used here, based on that used in the SSAGA interview (Bucholz *et al.*, 1994) is a very conservative one, and it is quite unlikely that any of these individuals would have experienced alcohol-related problems.

Table 1 summarizes the proportion of the sample

with more than minimal alcohol exposure ($n = 1846$) endorsing each of the symptoms assessed in the telephone interview. These figures of course represent respondents' lifetime (not necessarily current) experience. Recurrent hazardous alcohol use (endorsed by 38.9% of alcohol-exposed respondents), a recurrent desire to stop or cut down on drinking (25.4%), recurrent episodes of getting drunk when the respondent didn't want to (25.7%), and of drinking more or for more days in a row than intended (48.3%) were reported quite frequently. So also were the acquisition of tolerance to alcohol (38.9%, or 22.9% if we impose the requirement of

at least a 50% increase in how much the respondent would consume before getting drunk), and alcohol-related blackouts (30.5%, or 16.1% for recurrent blackouts). Reports of alcohol-related accidental injuries (14.8%), auto accidents (12.3%) and DUI arrests (9.3%) were not uncommon, though many fewer individuals reported recurrences of these events. In contrast, inability to stop or cut down on alcohol use (4.3%), giving up important activities while drinking (4.7%) or recurrent withdrawal symptoms (4.6%) or drinking to relieve withdrawal symptoms (3.1%) were all much rarer.

The simple breakdown of Table I suffers the important disadvantage that it conveys no information about the proportion of individuals endorsing a symptom who are reporting no other problems, and probably describing isolated incidents in their life. Greater insight was obtained through the use of latent class analysis. Under a 2-class model, we obtained a solution which identified a class with alcohol-related problems (class II; lifetime prevalence estimate of 19.5%) and a class with few or no problems (class I: 80.5%). Class II constituted 17.4% of the total sample, once non-exposed respondents were included, a figure only slightly lower than the lifetime prevalence of 20.1% reported for DSM-III-R alcohol dependence in adult males in the US National Comorbidity survey (Kessler *et al.*, 1994). Symptom endorsement probabilities for the two classes are summarized in Figure 2. Class II were particularly likely to report a recurrent desire to stop/cut down (66%), drinking more than intended (84%) and getting drunk when the respondent didn't want to (62%), at least one episode of alcohol-related problems with family or friends (49%, 34% for recurrent problems), acquisition of tolerance to alcohol (78%, or 55% if we use a 50% increase criterion for tolerance), alcohol-related auto accidents (37%) or injuries (41%), recurrent hazardous use (80%), alcohol-related blackouts (75%, or 54% for recurrent blackouts) and any alcohol-related health problems (34%). They were comparatively unlikely to report inability to stop drinking (18.1%) and withdrawal symptoms (19%) or drinking to relieve withdrawal symptoms (15%). As noted by Rindskopf & Rindskopf (1986), the 2-class solution in this case has a particularly appealing interpretation: the probability of endorsing an item given membership of the 'affected' class (class II) estimates the sensitivity of that item, and one minus the probability of endorsing that item given membership of the unaffected class (class I) gives the specificity of the item. Items

having relatively poor specificity included drinking more than intended (60%), tolerance without the 50% increase criterion (70%), any accidental injury (71%) and recurrent hazardous alcohol use (71%).

The 2-class solution gives us more insight into the common problems or experiences with alcohol that are co-occurring in individuals reporting multiple problems. However, it makes the strong assumption that our data are adequately described by two homogeneous groups, one with no or few problems, and one with more problems. Thus it ignores the possibility that there may be different subgroups of individuals with problems, perhaps having different symptom profiles. In Table 2, we compare the results of fitting 2-class, 3-class, 4-class, and 5-class models to these same data. For each of the 3-5 class models, the likelihood-ratio chi-square is highly significant, indicating a substantial improvement in fit compared to the model estimating one fewer class. From these analyses we cannot exclude the possibility that a model with 6, or possibly 7 or more classes would give a further significant statistical improvement in fit. However, we may note that even under the 5-class solution the population prevalence estimate for our smallest class is only 0.9%, so that approximately 16 individuals from the sample constituted that class. Thus from the viewpoint of generalizability of our findings it is probably not useful to continue to estimate further classes. In what follows, we will focus exclusively on the 5-class solution.

Symptom endorsement probabilities for the 5-class solution are summarized in Figure 3. In contrast to what has been reported by Kendler *et al.* (in review) for depressive symptoms, we found a striking absence of evidence for classes of respondents having distinctive alcoholism symptom profiles. Almost without exception, for each item the probability of endorsement increases monotonically as we move from the no problems class (class I) to the most severe (class V). The sole exception is observed for tolerance with 50% increase criterion, with a slightly lower endorsement probability for the most severe group than for the next most severe (class IV). This finding, which is consistent with results reported for a second large community sample of males (Slutske *et al.*, 1994) and for both male and female relatives of alcoholic probands (Bucholz, 1994), gives no support to the notion that individuals with alcohol-related problems can be subtyped on the basis of alcoholic symptomatology alone. Rather, it appears that there is a continuum of severity of alcohol-related problems.

Table 1. Endorsement frequencies for alcoholism symptoms by respondents with more than minimal alcohol exposure (n = 1846)

Recurrent desire to stop/cut down	25.4%	Arrested/detained for other drunken behavior	6.0%
Unable to stop when you wanted	4.3%	*Recurrent arrests for drunken behavior	0.7%
Drank more/more days in a row than intended repeatedly	48.3%	Accidental injury when drinking	14.8%
Drunk when didn't want to be repeatedly	25.7%	*Repeated accidental injuries when drinking	2.5%
Great deal of time spent drinking/recovering from effects of alcohol	8.0%	*Repeated hazardous alcohol use (e.g. drunk driving)	38.9%
Binged for 2 or more days and neglected responsibilities	2.2%	Blackouts (ever)	30.5%
Drinking caused problems with family or friends (ever)	11.7%	Recurrent blackouts	16.1%
Drinking caused recurrent problems with family or friends	7.6%	Repeated withdrawal symptoms	4.6%
Lost friends on account of drinking	2.7%	Repeated drinking to relieve withdrawal symptoms	3.1%
*Repeatedly lost friends on account of drinking	1.2%	*Withdrawal-induced fits/seizures	0.4%
Drinking caused problems at work or school (ever)	4.6%	*D'Ts	1.6%
Drinking caused recurrent problems at work or school	2.7%	Any alcohol-related health problem	8.9%
Tolerance	38.9%	**Continued to drink despite health problem	5.9%
Tolerance with 50% increase	22.9%	Continued to drink despite physical illness made worse by drinking	3.4%
Gave up/reduced important activities while drinking	4.7%	Mixed alcohol and medication when dangerous 3 or more times	6.6%
Repeatedly gave up important activities	3.1%	Drinking caused depression/loss of interest in things	4.9%
Being drunk or hungover interfered with responsibilities	6.2%	Jumpy/easily startled because of drinking	3.1%
Drinking caused problems in marriage/romantic relationship (ever)	5.7%	Trouble thinking clearly because of drinking	4.1%
Drinking caused repeated problems in marriage/romantic relationship	4.6%	Feeling paranoid or suspicious because of drinking	2.4%
Arrested for drunk driving (ever)	9.3%	Hearing, seeing or smelling things that weren't there because of drinking	1.0%
*Recurrent arrests for drunk driving	0.8%	Continued to drink despite emotional problems	4.0%
Drinking and driving caused accident (ever)	12.3%	Discussed drinking problems with professional	4.2%
*Drinking and driving caused repeated accidents	1.1%	Treated for a drinking problem	1.4%

*Not used in latent class analysis because of low endorsement frequency.

**Omitted because of technical problems.

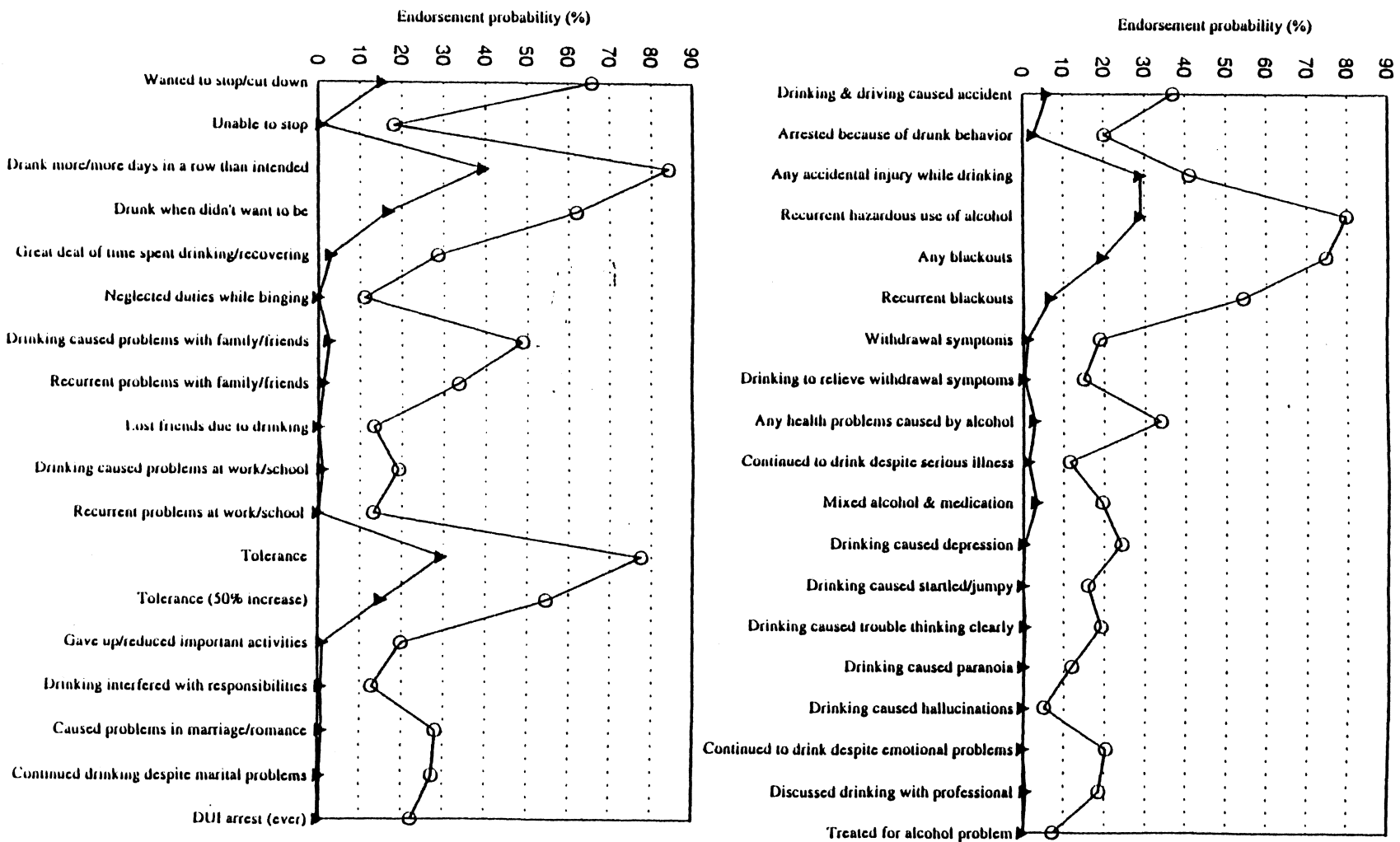


Figure 2. Symptom endorsement probabilities estimated by latent class analysis for the 2-class case. Class II (O), constituting 19.5% of the sample, have a substantially increased probability of endorsing alcohol-related problems. Class I (Δ) report few or no problems.

Table 2. Results of fitting latent class models to self-report alcoholism symptoms

Model	Log-likelihood	Likelihood-ratio test			Prevalence estimates				
	-2lnL	d.f.	χ^2	p	I	II	Class III	IV	V
2 Classes	30810.44	—	—	—	80.5%	19.5%	—	—	—
3 Classes	29266.52	39	1543.92	< 0.001	58.2%	36.7%	5.0%	—	—
4 Classes	28835.57	39	430.95	< 0.001	45.3%	39.8%	12.2%	2.7%	—
5 Classes	28657.18	39	178.39	< 0.001	42.2%	37.5%	15.7%	3.7%	0.9%

NB: Infrequent or light drinkers have been excluded from these analyses.

Class I, constituting 42.2% of the alcohol-exposed male respondents (48.6% of the entire sample, if we assume that all individuals with minimal alcohol exposure would fall into this class) reported no problems. They had only a modest probability of endorsing such items even as drinking more than intended (17.1%) or acquisition of tolerance (11.3%). Individuals in class II (37.5% of the alcohol-exposed, or 33.4% of the entire sample) are perhaps best described as sometime excessive drinkers (cf. Slutske *et al.*, 1994). They endorsed drinking more than intended (65%) and in some cases recurrent episodes of getting drunk when they didn't want to (34%). They were likely to report recurrent hazardous alcohol use (57%). They reported tolerance to alcohol (50%, or 25% using the criterion of at least a 50% increase), and blackouts (36%, or 15% for recurrent blackouts) and sometimes also a persistent desire to stop or cut down on alcohol use (26.8%). Probabilities of endorsement of any alcohol-related injuries (16.3%), alcohol-related auto accidents (11.8%) and alcohol-related DUIs (10.3%) were modest for group II, and for all other symptoms endorsement probabilities were negligible (< 10%). Together, classes I and II appeared to represent subgroupings of the 2-class solution unaffecteds.

Classes III, IV and V, which seem to represent individuals with mild, moderate and severe alcohol-related problems, had estimated population prevalences (for alcohol-exposed respondents) of 15.7%, 3.7% and 0.9% respectively (or 14.0%, 3.3% and 0.8% if we included those with minimal alcohol exposure). They may be considered, approximately, as representing subgroupings of the 2-class solution affecteds, with 20.3% of the respondents with more than minimal alcohol exposure (compared to 19.5% in the 2-class solution) falling into one of these three groups. The largest group (class III) differs from the class of excessive drinkers principally in having a greater probability of reporting a persistent desire to stop or cut down on drinking (57.6%) and an in-

creased probability of reporting alcohol-related problems with family or friends (40.1%, or 25.4% for recurrent problems), but also were more likely to report drinking more than intended, getting drunk when they didn't want to, alcohol-related tolerance and blackouts, and hazardous alcohol use. They had a very low probability of having any type of treatment contact (operationalized here to include both inpatient and outpatient programmes and use of AA or other self-help groups: 2.2%), and only a modest probability of having any professional contact regarding their drinking (13.9%). This group with mild problems represented 77% of the individuals from the three alcohol-problem classes. The most severe class had a much higher probability of having received any treatment for alcohol-related problems (62.4%) or having discussed alcohol problems with a professional (87.4%). Symptom endorsement probabilities for this group were much closer to what might be considered prototypical in narrow operationalizations of alcohol dependence, with high endorsement probabilities for most items including withdrawal symptoms (69%), drinking to relieve withdrawal symptoms (75%), inability to cut down on drinking (76%), a great deal of time spent using or recovering from the effects of alcohol (88%), and important activities given up because of drinking (69%). This severe group constituted only 4.2% of individuals in the three alcohol-related problem groups. Finally, group IV represents an intermediate group, much less likely to receive treatment (14%) or to have any professional contacts (27%) than group V, and also less likely to report alcohol-related withdrawal symptoms (33.3%) or drinking to relieve withdrawal symptoms (31.1%), but much more likely than group III to endorse continuing to drink despite emotional problems (64%), alcohol-related health problems (67%), a great deal of time spent using or recovering from the effects of alcohol (60%), inability to quit or cut down on drinking (41%), and any alcohol-related work or school problems (50.2%).

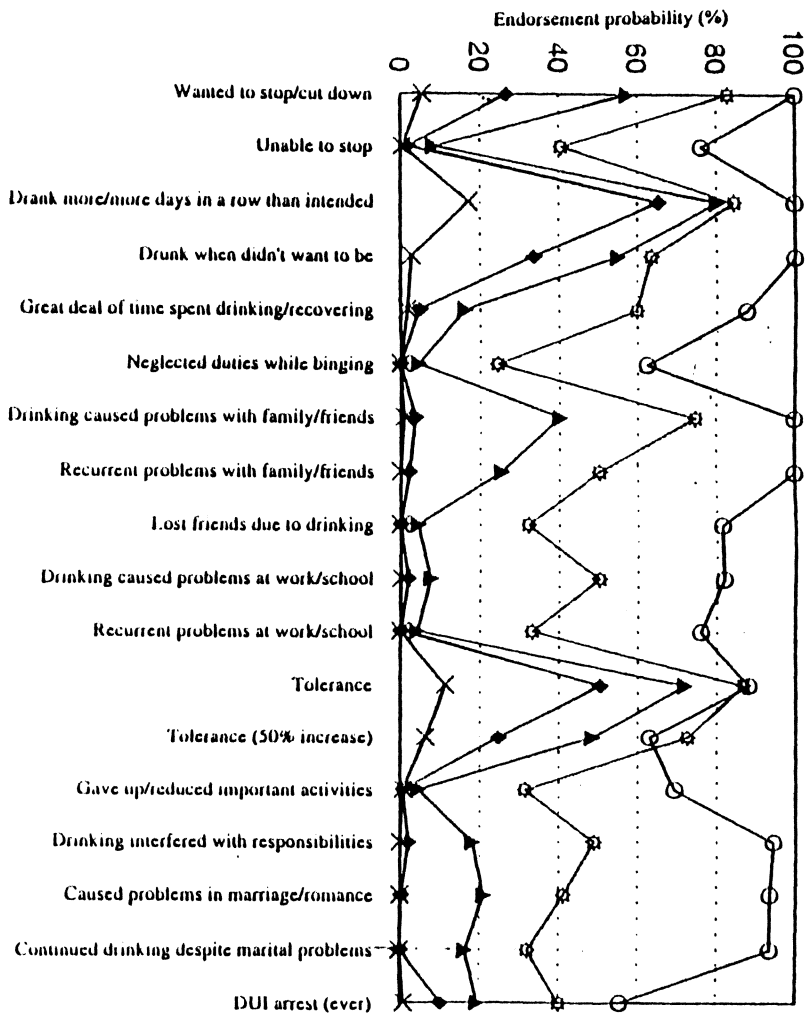
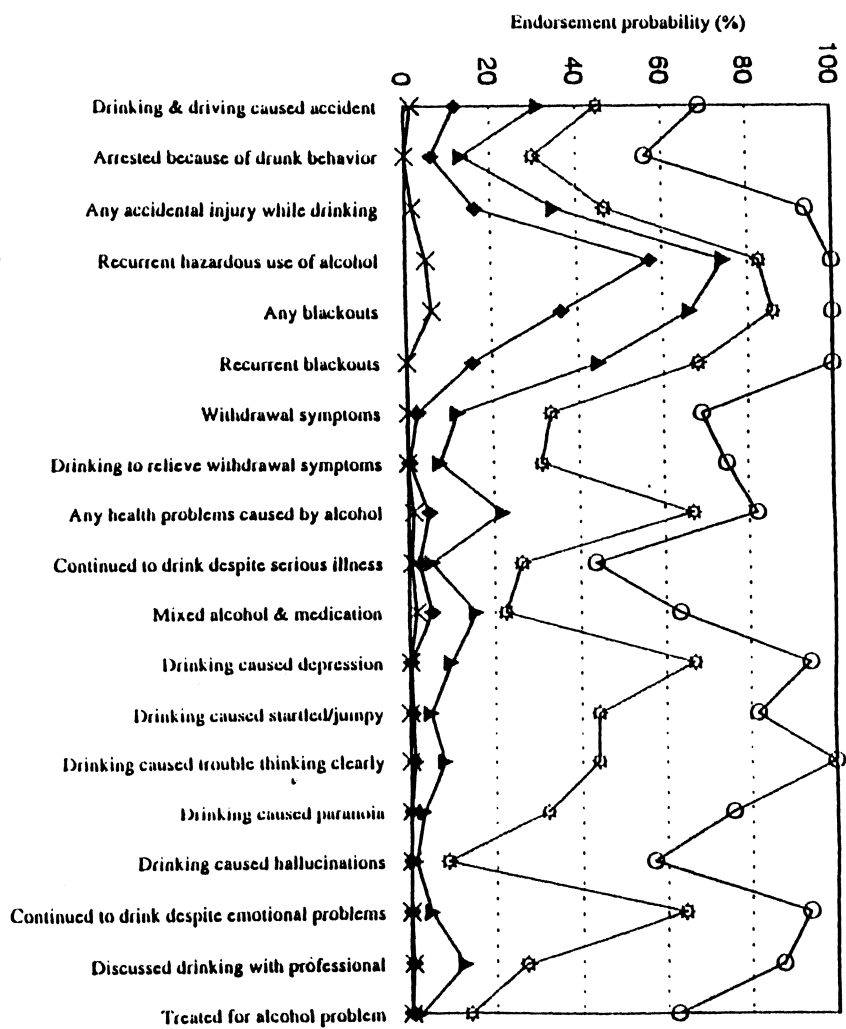


Figure 3. Symptom endorsement probabilities estimated by latent class analysis for the 5-class case (Class I, X, 42.2%; Class II, ♦, 37.5%; Class III, ▲, 15.7%; Class IV, △, 3.7%; Class V, ○, 0.9%).

Table 3. Expected breakdown of male twins reporting hazardous alcohol use, arrests or alcohol-related professional or treatment contacts, by latent class: 5-class solution (%)

	Class membership				
	I	II	III	IV	V
<i>Persons experiencing:</i>					
Recurrent hazardous use	5.2	54.8	29.9	7.8	2.3
Alcohol-related accidents	5.5	36.0	40.1	13.5	5.0
Alcohol-related injuries	6.5	21.0	49.4	15.5	7.6
DUI arrests	4.5	41.3	32.9	15.8	5.4
Arrests for other drunken behavior	0	38.7	34.7	18.3	8.4
Discussed drinking with professional	5.0	5.4	47.1	23.8	18.7
Treatment	0	0	24.3	36.2	39.5
Overall prevalence	49%	33%	14%	3%	1%

It would be easy to draw from these results the conclusion that only a minority of the cases experiencing alcohol-related problems that are identified in epidemiologic surveys are of the type that would be of particular interest to alcohol researchers or clinicians. This interpretation, however, would be a misreading of the data. In Table 3, we present selected results from Figure 3 in an alternative manner. From the class membership probabilities (equivalent to prevalence estimates), and the item endorsement probabilities for each class, we have computed the expected proportion of cases with a given outcome that derive from each of the severity classes estimated under the 5-class solution. Thus although the most severe class was associated with a very high probability of reporting alcohol-related treatment (62.4% versus 13.9% for class IV and 2.2% for class III), the prevalence of this class was very low, so individuals from this class represented only 40% of those reporting treatment, compared with 36% for class IV and 24% for class III. It should be noted, however, that because the number of treatment contacts (or other outcomes) was not assessed, Table 3 represents the distribution of persons experiencing a given outcome among the five severity classes, and not the distribution of outcomes. It is of course likely that persons in class V would have had more treatment contacts than those in classes IV or III.

Classes IV and V accounted for 76% of the respondents reporting any treatment. However, they accounted for less than 25% of the persons reporting recurrent hazardous alcohol use (10.1%), alcohol-related auto accidents (18.5%), alcohol-related injuries (23.1%) or DUI arrests (21.2%), and only 27.1% of the persons reporting arrests for drunken behavior (excluding DUI). In contrast, Class III, which accounted for the remaining 24% of persons reporting any treatment, included 30%

of the persons reporting hazardous alcohol use, approximately one-third of the persons reporting DUI arrests and reporting other alcohol-related arrests, 40% of the persons reporting alcohol-related auto accidents, and 49% of the persons reporting alcohol-related injuries. For class III the probability of ever having discussed any problem with their drinking with a professional was only 13%, although this class accounted for 47% of all persons reporting that they have discussed their drinking. In contrast even to class III, the excessive drinkers (class II) included no individuals who have been treated and only 5.4% of those reporting professional contacts, but included 55% of those reporting recurrent hazardous alcohol use, 41% of those reporting DUI arrests and 39% of those reporting arrests for other drunken behavior, 36% of those reporting alcohol-related accidents, and 21% of those reporting alcohol-related injuries. As many previously have noted, it would be a serious mistake to dismiss the excessive drinkers and mild problem drinkers as being of no import.

Discussion

The primary goal of this paper was to re-examine the question of what we may learn from large epidemiologic surveys of community samples (e.g. Robins & Regier, 1991; Kessler *et al.*, 1994), including genetic studies using twin or other designs (Kendler *et al.*, 1992, 1994; Kendler, 1993). As we have been able to show using data from the Australian twin panel, analyzed using latent class models, the majority of cases identified in such surveys will be individuals with a history of only mild problems. Because these individuals, together with excessive drinkers, account for a substantial proportion of the persons experiencing alcohol-

related accidents, injuries, arrests, or other harmful consequences of alcohol use, they represent an important group to study from the public health perspective. (This is the familiar 'prevention paradox' that applies equally to heart disease or many other medical conditions: because severe cases are rare, prevention or intervention must focus on less severe cases to have a major impact). Yet these two groups have a low probability of receiving treatment or even discussing with a physician or other professional concerns about their drinking, making them a difficult group to study outside the context of large-scale epidemiologic and genetic epidemiologic research. It is unfortunate that most such studies have been cross-sectional in design, and have assessed only a narrow range of pertinent risk-factors. As follow-up studies are conducted on such samples, we may hope that greater insights will emerge into the etiology of excessive drinking and mild alcohol-related problems.

As a consequence of the relatively small proportion of severe cases represented in community samples, it cannot automatically be assumed that inferences about alcoholism etiology derived from such samples, which will be largely based on findings for mild cases, can be generalized to severe cases. We cannot yet be certain about how well findings for the genetic contribution to alcoholism risk based on community twin samples (Kendler *et al.*, 1992; Heath *et al.*, 1995) can be applied to severe cases seen in treatment settings. Results from our latent class analyses support a continuum model for the severity of alcohol-related problems, as also do analyses reported for other data-sets (Slutske *et al.*, 1994; Bucholz, 1994), which would suggest that findings can be usefully generalized. From such community samples, however, our power of determining whether there exists subtypes of severe alcoholism having a distinct mode of inheritance will be limited (Neale, unpublished data). For such purposes data on severe alcoholic probands identified through treatment facilities, and their relatives, are likely to be much more informative.

As we have found here in analyses of the Australian male data, a latent class analysis approach also provides useful information about how psychiatric diagnostic criteria (e.g. DSM-IV or DSM-III-R: APA, 1987; 1994), as operationalized in one particular structured or semi-structured interview (in this case, with minor adaptations, the SSAGA: Bucholz *et al.*, 1994), perform in a community sample. In this community sample of Australian males, items relating to the persistent desire to stop or cut

down on drinking, and the inability to cut down on drinking, although compounded together in a single diagnostic criterion, are behaving very differently, with the former endorsed with 57% probability by the mild problem class and the latter with very low probability (8%), compared to 83% and 41% probabilities for the moderate problem class and 100% and 76% for the severe problem class. One component of the criterion is apparently more useful for detecting mild cases and the other for detecting moderate to severe cases. While continuing to drink despite alcohol-related blackouts has been offered as one example of continued alcohol use despite alcohol-related health problems (APA, 1994), the endorsement probability for recurrent blackouts by the mild problem group is twice as high as that for alcohol-related health problems (44.7% versus 22%). Without the requirement of at least a 50% increase, tolerance as operationalized here is endorsed with high probability even by the class of excessive drinkers (50%). If the 50% increase criterion is used, it discriminates very poorly between mild, moderate and severe problem classes. The use of tolerance to identify a (presumably more severe) subset of cases with 'physiological dependence' (APA, 1994) thus appears unjustified, unless perhaps the operationalization of the construct in structured and semi-structured diagnostic interviews is revised to substantially increase the level of alcohol consumption at which tolerance is inferred.

As in the tolerance example, an approach using latent class analysis may be particularly useful in fine-tuning assessment instruments to achieve particular goals. As used in the Australian study, drinking more than intended does a reasonable job of detecting excessive drinkers (endorsement probability 65%), but discriminates poorly between excessive drinkers and those with more severe problems. Recurrent hazardous alcohol use behaves in a similar fashion, with an endorsement probability of 57% for the excessive drinker class. In each case addition of a subquestion using a more stringent definition of frequent use that is hazardous or much more than intended would probably improve discrimination between these latter groups. In contrast, items such as continued alcohol use despite emotional problems, alcohol-related health problems, or a great deal of time spent using or recovering from the effects of alcohol, have a high probability of endorsement by moderate or severe problem classes, but a very low probability by excessive drinker or mild problem classes, and would be of only limited utility for detecting these latter cases.

The analyses presented in this paper will, we hope, have demonstrated the utility of applying latent class models to psychiatric symptom data. As we noted in the introduction, there are many more powerful applications of latent class analysis than the simple analysis of cross-sectional data on a sample of unrelated individuals that we have used here—including the application to family or other genetic data, to longitudinal data, and to multiple-informant data. The analyses which we have presented must be viewed as 'exploratory', by analogy with factor analysis (Harman, 1976). It remains to be seen how well these results will replicate in the female twins from the Australian sample, and in other samples assessed using different instruments, or ascertained using different sampling schemes, or in other cultures.

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References

- AMERICAN PSYCHIATRIC ASSOCIATION (1987) *Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised* (Washington, DC, American Psychiatric Association).
- AMERICAN PSYCHIATRIC ASSOCIATION (1994) *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (Washington, DC, American Psychiatric Association).
- BUCHOLZ, K. K., CADORET, R., CLONINGER, C. R., DINWIDDIE, S. H., HESSELBROCK, V. M., NURNBERGER, J. I., 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, pp. 149–158.
- BUCHOLZ, K. K. (1994) *Gender differences in nosological phenotypes of alcohol dependence*. Paper presented at Research Society on Alcoholism Annual Scientific Meeting, June 18–23, Maui, Hawaii.
- CASTLE, D. J., SHAM, P. C., HESSELEY, S. & MURRAY, R. M. (1994) The subtyping of schizophrenia in men and women: a latent class analysis, *Psychological Medicine*, 24, pp. 41–51.
- CLOGG, C. C. (1977) *Unrestricted and Restricted Maximum Likelihood Latent Structure Analysis: A Manual for Users* (University Park, PA, Population Issues Research Office).
- COLLINS L. M. (1991) The measurement of dynamic latent variables in longitudinal aging research: quantifying adult development, *Experimental Aging Research*, 17, pp. 13–20.
- EATON, W. W., DRYMAN, A., SORENSON, A. & MC-CUTCHEON, A. (1989) DSM-III major depressive disorder in the community. A latent class analysis of data from the NIMH epidemiologic catchment area programme, *British Journal of Psychiatry*, 155, pp. 48–54.
- EAVES L. J., SILBERG, J. L., HEWITT, J. K., RUTTER, M., MEYER, J. M., NEALE, M. C. & PICKLES, A. (1993) Analyzing twin resemblance in multisymptom data: Genetic applications of a latent class model for symptoms of conduct disorder in juvenile boys, *Behavior Genetics*, 23, pp. 5–19.
- FARAONE, S. V. & TSUANG, M. T. (1994) Measuring diagnostic accuracy in the absence of a 'gold standard', *American Journal of Psychiatry*, 151, pp. 650–657.
- FERGUSON, D. M., HORWOOD L. J. & LYNKEY, M. T. (1993) Prevalence and comorbidity of DSM-III-R diagnoses in a birth cohort of 15 year olds, *Journal of the American Academy of Child & Adolescent Psychiatry*, 32, pp. 1127–1134.
- GOODMAN, L. A. (1974) The analysis of systems of qualitative variables when some of the variables are unobservable. Part I: a modified latent structure approach, *American Journal of Sociology*, 79, pp. 1179–1259.
- GRAHAM, J. W., COLLINS, L. M., WUGALTER, S. E., CHUNG, N. K. & HANSEN, W. B. (1991) Modeling transitions in latent stage-sequential processes: a substance use prevention example, *Journal of Consulting and Clinical Psychology*, 59, pp. 48–57.
- GROVE, W. M., ANDREASEN, N. C., YOUNG, M., ENDICOTT, J., KELLER, M. B., HIRSCHFELD, R. M. & REICH, T. (1987) Isolation and characterization of a nuclear depressive syndrome, *Psychological Medicine*, 17, pp. 471–84.
- HARMAN, H. (1976) *Modern Factor Analysis* (Chicago, IL, University of Chicago Press).
- HEATH, A. C., MEYER, J., EAVES, L. J. & MARTIN, N. G. (1991a) The inheritance of alcohol consumption patterns in a general population twin sample: I. Multidimensional scaling of quantity/frequency data, *Journal of Studies on Alcohol*, 52, pp. 345–352.
- HEATH, A. C., MEYER, J., JARDINE, R. & MARTIN, N. G. (1991b) The inheritance of alcohol consumption patterns in a general population twin sample: II. Determinants of consumption frequency and quantity consumed, *Journal of Studies on Alcohol*, 52, pp. 425–433.
- HEATH, A. C. & MARTIN, N. G. (1991) Intoxication after an acute dose of alcohol: An assessment of its association with alcohol consumption patterns by using twin data, *Alcoholism: Clinical and Experimental Research*, 15, pp. 122–128.
- 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, pp. 762–775.
- HEATH, A. C. & MARTIN, N. G. (1994) Genetic influences on alcohol consumption patterns and problem drinking: Results from the Australian NH&MRC Twin Panel follow-up survey, *Annals of the New York Academy of Science*, 708, pp. 72–85.
- HEATH, A. C., SLUTSKE, W. S., MADDEN, P. A. F.,

- BUCHOLZ, K. K., DINWIDDIE, S. H., WHITFIELD, J., DUNNE, M. P., STATHAM, D. & MARTIN, N. G. (1995) Genetic effects on alcohol consumption patterns and problems in women, *Alcohol and Alcoholism*, in press.
- JARDINE, R. & MARTIN, N. G. (1981) Causes of variation in drinking habits in a large twin sample, *Acta Geneticae Medicae et Gemellologiae*, 33, pp. 435-450.
- KENDLER, K. S. (1993) Twin studies of psychiatric illness: Current status and future directions, *Archives of General Psychiatry*, 50, pp. 905-915.
- KENDLER, K. S., HEATH, A. C., NEALE, M. C., KESSLER, R. C. & EAVES, L. J. (1992) A population-based twin study of alcoholism in women, *Journal of the American Medical Association*, 268, pp. 1877-1882.
- KENDLER, K. S., NEALE, M. C., HEATH, A. C., KESSLER, R. C. & EAVES, L. J. (1994) A twin-family study of alcoholism in women, *American Journal of Psychiatry*, 151, pp. 707-715.
- KENDLER, K. S., EAVES, L. J., WALTERS, E. E., NEALE, M. C., HEATH, A. C. & KESSLER, R. C. (1995) Depressive syndromes in a population-based sample of female twins: The application of latent class analysis. (In review).
- KESSLER, R. C., MCGONAGLE, K. A., ZHAO, S., NELSON, C. B., HUGHES, M., ESHLEMAN, S., WITCHEN, H.-U. & KENDLER, K. S. (1994) Lifetime and 12-month prevalence of DSM-III-R psychiatric disorders in the United States, *Archives of General Psychiatry*, 51, pp. 8-19.
- LENZENWEGER, M. F., DWORKIN, R. H. & WETHINGTON, E. (1991) Examining the underlying structure of schizophrenic phenomenology: evidence for a three-process model, *Schizophrenia Bulletin*, 17, pp. 515-524.
- MCCUTCHEON, A. L. (1987) *Latent Class Analysis* (Newbury Park, Sage Publications).
- MARTIN, N. G., PERL, J., OAKESHOTT, J. G., GIBSON, J. B., STARMER, G. A. & WILKS, A. V. (1985a) A twin study of ethanol metabolism, *Behavior Genetics*, 15, pp. 93-109.
- MARTIN, N. G., OAKESHOTT, J. G., GIBSON, J. B., STARMER, G. A., PERL, J. & WILKS, A. V. (1985b) A twin study of psychomotor and physiological responses to an acute dose of alcohol, *Behavior Genetics*, 15, pp. 305-347.
- PARKER, G., HADZI-PAVLOVIC, D., BOYCE, P., WILHELM, K., BRODATY, H., MITCHELL, P., HICKIE, I. & EYSERS, K. (1990) Classifying depression by mental state signs, *British Journal of Psychiatry*, 157, pp. 55-65.
- RINDSKOPF, P. & RINDSKOPF, D. (1986) The value of latent class analysis in medical diagnosis, *Statistics in Medicine*, 5, pp. 21-27.
- ROBINS, L. N. & REGIER, D. A. (1991) *Psychiatric Disorders in America* (New York, NY, Free Press).
- SLUTSKE, W. S., EAVES, L. J., HEATH, A. C., TRUE, W., EISEN, S., LIN, N., LYONS, M. & TSUANG, M. (1994) *An examination of the underlying structure of alcohol problems in male twins*. Paper presented at 24th annual meeting of Behavior Genetics Association, July 7-10, Barcelona, Spain.
- UEBERSAX, J. S. & GROVE, W. M. (1990) Latent class analysis of diagnostic agreement, *Statistics in Medicine*, 9, pp. 559-572.
- WALTER, S. D. & IRWIG, L. M. (1988) Estimation of test error rates, disease prevalence and relative risk from misclassified data: a review, *Journal of Clinical Epidemiology*, 41, pp. 923-937.
- WALTER, S. D., FROMMER, D. J. & COOK, R. J. (1991) The estimation of sensitivity and specificity in colorectal cancer screening methods, *Cancer Detection and Prevention*, 15, pp. 465-469.
- YOUNG, M. (1982-3) Evaluating diagnostic criteria: a latent class paradigm, *Journal of Psychiatric Research*, 17, pp. 285-296.