Trends in adolescent alcohol use: Effects of age, sex and cohort. Lot M Geels, Meike Bartels, Toos C.E.M. van Beijsterveldt, Gonneke A.H.M. Willemsen, Niels van der Aa, Jacqueline M Vink & Dorret I Boomsma

Supplementary materials

1. The frequencies of alcohol frequency and quantity in the original categories are shown in Table 1, as a function of cohort, age and gender.

Table 1. Frequencies (percentages) of alcohol frequency and quantity in the original categories for each cohort, age group and gender

	Male		Female	
Frequency	1993	2005-8	1993	2005-8
Age 13-15				
Never	32.5	28.9	40.7	28.7
Once a year or less	14.6	11.0	18.5	12.3
Several times a year	27.7	26.1	24.3	26.6
About once a month	7.6	10.3	4.8	11.3
Several times a month	9.4	11.1	6.0	10.5
Once a week	5.8	8.1	5.0	6.2
Several times a week	2.4	1.7	.8	1.6
Daily	-	.1	-	.0
	N=501	*N=1679*	*N=605*	*N=2116*
Age 16-17				
Never	12.9	6.8	10.3	7.0
Once a year or less	4.8	2.8	9.0	3.7
Several times a year	16.2	8.7	24.1	14.6
About once a month	9.2	6.8	13.7	12.0
Several times a month	13.7	17.0	17.5	21.5
Once a week	25.2	29.1	17.1	26.3
Several times a week	17.4	23.4	8.3	10.3
Daily	.6	.8	-	.2
	N=357	*N=1290*	*N=468*	*N=1729*
Age 18-21				
Never	4.0	3.2	7.8	5.3
Once a year or less	3.8	1.5	6.0	2.7
Several times a year	7.2	5.4	15.3	12.1
About once a month	3.8	4.3	11.3	12.4
Several times a month	12.0	14.8	18.1	22.1
Once a week	22.7	24.7	23.8	22.6
Several times a week	42.3	39.1	16.7	18.3
Daily	4.1	3.2	1.3	.7
	N=607	*N=448*	*N=720*	*N=775*

	Male		Female	
Quantity	1993	2005-8	1993	2005-8
Age 13-15				
Less than 1 glass	85.1	53.5	88.1	52.7
1-2 glasses	9.4	9.8	7.0	8.9

3-5 glasses	3.4	3.7	3.8	4.1
6-10 glasses	1.7	1.3	.5	1.4
11-16 glasses	.3	.3	.3	.3
17-20 glasses	-	.1	-	.0
More than 20 glasses	-	.1	-	-
	N=350	*N=1185*	*N=369*	*N=1467*
Age 16-17				
Less than 1 glass	39.2	25.4	60.0	36.7
1-2 glasses	17.2	18.7	18.9	21.5
3-5 glasses	16.5	21.9	12.6	24.5
6-10 glasses	16.2	20.9	6.3	13.2
11-16 glasses	4.4	8.2	1.0	3.1
17-20 glasses	4.3	4.8	.9	1.1
More than 20 glasses	2.3	.2	.2	-
	N=309	*N=1190*	*N=413*	*N=1603*
Age 18-21				
Less than 1 glass	17.8	12.7	44.7	30.2
1-2 glasses	12.9	10.9	17.7	18.8
3-5 glasses	16.2	21.2	17.7	22.1
6-10 glasses	22.6	21.7	13.4	12.9
11-16 glasses	9.0	16.5	2.6	4.6
17-20 glasses	9.8	10.5	2.1	3.0
More than 20 glasses	11.8	.4	1.8	-
	N=580	*N=438*	*N=657*	*N=737*

2. Univariate saturated models were fitted to alcohol initiation, frequency and quantity in each age group and cohort to test for cohort- and sex differences in thresholds and correlation structure. In all full models, the following parameters were estimated:

- threshold(s) for males, threshold(s) for females in the 1993 cohort
- threshold(s) for males, threshold(s) for females in the 2005-8 cohort
- twin correlations for all five zygosity groups in the 1993 cohort (see Table 2 below)
- twin correlations for all five zygosity groups in the 2005-8 cohort (see Table 2 below)

Table 2. Tetra- and polychoric twin correlations with 95% confidence intervals for alcohol initiation, frequency and quantity in each age group and cohort, estimated in full saturated models

	1993			2005-8		
	Age 13-15	Age 16-17	Age 18-21	Age 13-15	Age 16-17	Age 18-21

Initiation						
MZM	.83 (.65 - .94)	-	-	.81 (.71 - .89)	-	-
DZM	.72 (.43 - .90)	-	-	.68 (.51 - .81)	-	-
MZF	.88 (.76 - .95)	-	-	.88 (.82 - .93)	-	-
DZF	.83 (.63 - .94)	-	-	.81 (.68 - .89)	-	-
DOS	.62 (.40 - .78)	-	-	.66 (.55 - .75)	-	-
Frequency						
MZM	.90 (.79 - .96)	.83 (.67 - .92)	.63 (.45 - .76)	.77 (.69 - .83)	.67 (.58 - .75)	.69 (.49 - .82)
DZM	.81 (.61 - .91)	.77 (.56 - .89)	.46 (.21 - .65)	.66 (.55 - .75)	.53 (.38 - .65)	.35 (.04 - .60)
MZF	.87 (.77 - .94)	.80 (.68 - .88)	.68 (.56 - .78)	.86 (.81 - .89)	.78 (.72 - .84)	.60 (.44 - .72)
DZF	.75 (.53 - .87)	.67 (.47 - .81)	.67 (.50 - .79)	.79 (.72 - .85)	.54 (.41 - .65)	.36 (.14 - .55)
DOS	.62 (.42 - .75)	.43 (.19 - .62)	.34 (.15 - .51)	.59 (.51 - .66)	.53 (.43 - .61)	.33 (.11 - .51)
Quantity						
MZM	-	.82 (.63 - .92)	.60 (.41 - .74)	-	.79 (.70 - .85)	.54 (.28 - .72)
DZM	-	.46 (.13 - .70)	.53 (.29 - .71)	-	.49 (.30 - .64)	.39 (.05 - .64)
MZF	-	.79 (.62 - .89)	.77 (.63 - .86)	-	.73 (.64 - .79)	.73 (.60 - .83)
DZF	-	.66 (.42 - .82)	.62 (.39 - .78)	-	.61 (.49 - .71)	.63 (.41 - .78)
DOS	-	.43 (.17 - .63)	.25 (.04 - .43)	-	.42 (.29 - .54)	.39 (.18 - .57)

Note. MZM=monozygotic male, DZM=dizygotic male, MZF=monozygotic female, DZF=dizygotic female, DOS=dizygotic opposite sex. Correlations for alcohol initiation were only computed at age 13-15, because at older ages the prevalence was nearly 100%.

Saturated model testing

The full models (model 1) were the starting point from which nested models were tested. Whenever the deterioration in model fit of a nested model was nonsignificant, the restrictions of that model were also applied to the following models nested under that.
Model 2: Thresholds were equated across the cohorts, but still estimated separately for males and females. No restrictions were done on the twin correlations.
Model 3: Thresholds were equated across males and females, no restrictions were done on the twin correlations.
Model 4: Twin correlations in all zygosity groups were equated across cohorts, but still estimated separately for males and females.
Model 5: The monozygotic male twin correlation was equated to the monozygotic female twin correlation, and the dizygotic male twin correlation was equated to the dizygotic female twin correlation and to the dizygotic opposite sex correlation. In case equating the dizygotic twin correlations resulted in worsening of model fit, the DOS correlation was estimated, and equating it to the dizygotic correlation was tested separately in an additional submodel (model 6).
Model 6: The dizygotic opposite sex twin correlation was equated to the dizygotic twin correlation (which was already equated across males and females in model 5).

Table 3. Initiation of alcohol use: test for cohort- and sex differences in thresholds and correlation structure using univariate saturated models

	n par	-2 LL (df)	X^2 (Δ df)	P	vs

		n par	-2 LL (df)	X^2 (Δ df)	P	vs
Age 13-15						
model 1	Full model: thresholds equated across birth order and zygosity within sex and cohort	14	5199.996 (4930)			
model 2	As 1 plus thresholds equated across cohorts	12	5238.884 (4932)	38.888 (2)	<.0001	1
model 3	As 1 plus thresholds equated across sex	12	5209.887 (4932)	9.891 (2)	.0071	1
model 4	As 3 plus correlations equated across cohorts	7	5200.408 (4935)	.412 (7)	.9997	1
model 5	As 4 plus correlations equated across sex	4	5208.597 (4938)	8.189 (3)	.0423	4

Note. n par: number of parameters estimated; -2LL: -2 loglikelihood. χ^2 (Δdf): likelihood ratio test value and difference degrees of freedom; vs: the model to which the submodel is compared. Likelihood ratio tests were evaluated at alpha=.01.
Initiation of alcohol use was not examined in age groups 16-17 and 18-21 because the prevalence was close to 100%.

Table 4. Frequency of alcohol use: test for cohort- and sex differences in thresholds and correlation structure using univariate saturated models

		n par	-2 LL (df)	X^2 (Δ df)	P	vs
Age 13-15						
model 1	Full model: thresholds equated across birth order and zygosity within sex and cohort	18	8657.526 (4748)			
model 2	As 1 plus thresholds equated across cohorts	14	8743.615 (4752)	86.089 (4)	<.0001	1
model 3	As 1 plus thresholds equated across sex	14	8673.834 (4752)	16.308 (4)	.0026	1
model 4	As 3 plus correlations equated across cohorts	13	8664.310 (4753)	6.784 (5)	.2372	1
model 5	As 4 plus correlations equated across sex (not DOS)	11	8672.277 (4755)	7.967 (2)	.0186	4
model 6	As 5 plus DOS correlation equated to DZ correlation	10	8683.761 (4756)	11.484 (1)	.0007	5
Age 16-17						
model 1	Full model: thresholds equated across birth order and zygosity within sex and cohort	18	7481.531 (3814)			
model 2	As 1 plus thresholds equated across cohorts	14	7491.107 (3818)	9.756 (4)	.0477	1
model 3	As 1 plus thresholds equated across sex	12	7587.057 (3820)	95.950 (2)	<.0001	2
model 4	As 1 plus correlations equated across cohorts	9	7496.276 (3823)	5.169 (5)	.3956	2
model 5	As 1 plus correlations equated across sex	6	7499.020 (3826)	2.744 (3)	.4328	4
Age 18-21						
model 1	Full model: thresholds equated across birth order and zygosity within sex and cohort	18	5032.899 (2531)			
model 2	As 1 plus thresholds equated across cohorts	14	5043.393 (2535)	10.494 (4)	.0329	1
model 3	As 1 plus thresholds equated across sex	12	5244.100 (2537)	200.707 (2)	<.0001	2
model 4	As 1 plus correlations equated across cohorts	9	5050.306 (2540)	6.913 (5)	.2272	2
model 5	As 4 plus correlations equated across sex	6	5053.792 (2543)	3.484 (3)	.3228	4

Note. n par: number of parameters estimated; -2LL: -2 loglikelihood. χ^2 (Δdf): likelihood ratio test value and difference degrees of freedom; vs: the model to which the submodel is compared. Likelihood ratio tests were evaluated at alpha=.01.

Table 5. Quantity of alcohol use: test for cohort- and sex differences in thresholds and correlation structure using univariate saturated models

		n par	-2 LL (df)	X^2 (Δ df)	P	Vs

Age 16-17						
model 1	Full model: thresholds equated across birth order and zygosity within sex and cohort	18	6785.585 (3491)			
model 2	As 1 plus thresholds equated across cohorts	14	6858.556 (3495)	73.006 (4)	<.0001	1
model 3	As 1 plus thresholds equated across sex	14	6925.546 (3495)	139.961 (4)	<.0001	1
model 4	As 3 plus correlations equated across cohorts	9	6786.615 (3496)	1.030 (5)	.9601	1
model 5	As 4 plus correlations equated across sex	6	6794.950 (3499)	8.335 (3)	.0396	4
Age 18-21						
model 1	Full model: thresholds equated across birth order and zygosity within sex and cohort	18	4401.021 (2393)			
model 2	As 1 plus thresholds equated across cohorts	14	4418.124 (2397)	17.103 (4)	.0018	1
model 3	As 1 plus thresholds equated across sex	14	4657.316 (2397)	239.192 (4)	<.0001	1
model 4	As 1 plus correlations equated across cohorts	13	4403.084 (2398)	2.063 (5)	.8404	1
model 5	As 4 plus correlations equated across sex (not DOS)	11	4410.051 (2400)	6.967 (2)	.0307	4
model 6	As 5 plus DOS correlation equated to DZ correlation	10	4417.717 (2401)	7.666 (1)	.0056	5

Note. n par: number of parameters estimated; -2LL: -2 loglikelihood. χ^2 (Δdf): likelihood ratio test value and difference degrees of freedom; vs: the model to which the submodel is compared. Likelihood ratio tests were evaluated at alpha=.01.

3. The liability structure of alcohol initiation and frequency/quantity was examined in the 13-15 age group by comparing three multivariate saturated models specifying different liability structures (single liability, independent liabilities or combined liabilities). Analyses were done within cohorts. The best fitting model has the least significant χ^2-value and the lowest AIC.

Table 6. Goodness-of-fit of the SLD, ILD and Combined Model to alcohol frequency and initiation at age 13-15, within cohorts

	n par	χ^2 (df)	P	AIC
1993				
Age 13-15				
Single liability dimension (SLD)	11	86.648 (64)	.0302	-41.352
Independent liability dimension (ILD)	16	371.185 (59)	<.0001	253.185
Combined model (CM)	18	62.040 (57)	.3012	-51.960
2005-8				
Age 13-15				
Single liability dimension (SLD)	11	152.357 (64)	<.0001	24.357
Independent liability dimension (ILD)	16	736.273 (59)	<.0001	618.273
Combined model (CM)	18	80.599 (57)	.0215	-33.401

Note. n par: number of parameters estimated; χ^2 (df): tests goodness of fit; AIC = χ^2 - 2df, a measure of parsimony of the model

4. Univariate variance decomposition of alcohol initiation at age 13-15 on combined cohorts (thresholds and variance components constrained based on twin correlations).

Table 7. Univariate variance decomposition of alcohol initiation: model fitting results in age groups 13-15 and 16-17,

on pooled cohorts

		n par	-2LL (df)	χ^2 (Δdf)	p	Vs
Age 13-15						
model 1	ACE model without sex difference	6	5208.597 (4941)			
model 2	CE model	5	5226.436 (4942)	17.839 (1)	<.0001	1
model 3	AE model	5	5264.534 (4942)	55.937 (1)	<.0001	1

Note. A: additive genetic variance component; C: common environmental variance component; E: unique environmental variance component; n par: number of parameters estimated; -2LL: -2 loglikelihood; χ^2 (Δdf): likelihood ratio test value and difference degrees of freedom; vs: the model to which the submodel is compared. Likelihood ratio tests were evaluated at alpha=.01. Separate thresholds were estimated for each cohort and gender.

5. Variance decompositions were done under the best fitting liability models, with thresholds and correlation structure specified according to results from univariate saturated models.

In the 13-15 age group variance components were estimated under combined models. This model is optimized through a user-defined fit function and does not compute a -2 loglikelihood of the data. Determining the significance of the variance components was therefore done by comparing the χ^2-goodness-of-fit statistic and the AICs and choosing the best fitting model from the submodels.

Table 8. Variance decomposition under the Combined model: model fitting results for alcohol frequency combined with initiation, age group 13-15, on pooled cohorts

	Initiation	*Frequency*	n par	χ^2 (df)	p	AIC
1.	ACE	ACE	20	169.989 (130)	.0106	-90.011
2.	CE	ACE	19	173.471 (131)	.0077	-88.529
3.	AE	ACE	19	184.971 (131)	.0013	-77.029
4.	ACE	CE	19	179.624 (131)	.0031	-82.376
5.	ACE	AE	19	223.122 (131)	<.0001	-38.878

Note. ACE = full model without sex differences; AE = additive genetic model; CE = shared environmental model; n par: number of parameters estimated; χ^2 (Δdf): tests goodness of fit; AIC = χ^2 - 2df, a measure of parsimony of the model
Thresholds were estimated separately for each cohort and gender.

In the 16-17 and 18-21 age groups, a single liability model was used for the variance decomposition, which amounts to a univariate analysis (initiation and frequency/quantity are on the same liability distribution). Therefore the significance of the variance components was determined by dropping them from the model one at a time and evaluating the difference in model fit.

Table 9. Variance decomposition under the Single Liability Dimension model: model fitting results for alcohol frequency and quantity, age group 16-17, on pooled cohorts

		n par	-2LL (df)	χ^2 (Δdf)	p	vs

		n par	-2LL (df)	χ^2 (Δdf)	p	vs
Frequency						
model 1	ACE model without sex difference	8	7696.415 (3490)			
model 2	CE model	7	7740.270 (3491)	43.855 (1)	<.0001	1
model 3	AE model	7	7729.914 (3491)	33.499 (1)	<.0001	1
Quantity						
model 1	ACE model without sex difference	14	7111.956 (3222)			
model 2	CE model	13	7176.908 (3223)	64.952 (1)	<.0001	1
model 3	AE model	13	7123.571 (3223)	11.615 (1)	.0007	1

Note. A: additive genetic variance component; C: common environmental variance component; E: unique environmental variance component; n par: number of parameters estimated; -2LL: -2 loglikelihood; χ^2 (Δdf): likelihood ratio test value and difference degrees of freedom; vs: the model to which the submodel is compared. Likelihood ratio tests were evaluated at alpha=.01.
Incomplete twin pairs were excluded from the analyses. For alcohol frequency, thresholds were equated across cohorts but separate thresholds were estimated for boys/girls. For quantity, thresholds were estimated separately for each cohort and gender.

Table 10. Variance decomposition under the Single Liability Dimension model: model fitting results for alcohol frequency and quantity in age group 18-21, on pooled cohorts

		n par	-2LL (df)	χ^2 (Δdf)	p	vs
Frequency						
model 1	ACE model without sex difference	8	5031.778 (2306)			
model 2	CE model	7	5053.232 (2307)	21.454 (1)	<.0001	1
model 3	AE model	7	5035.596 (2307)	3.818 (1)	.0507	1
Quantity						
model 1	ACE model without sex difference	15	4309.554 (2119)			
model 2	CE model	14	4329.840 (2120)	20.286 (1)	<.0001	1
model 3	AE model	14	4321.560 (2120)	12.006 (1)	.0005	1

Note. A: additive genetic variance component; C: common environmental variance component; E: unique environmental variance component; n par: number of parameters estimated; -2LL: -2 loglikelihood; χ^2 (Δdf): likelihood ratio test value and difference degrees of freedom; vs: the model to which the submodel is compared. Likelihood ratio tests were evaluated at alpha=.01
Incomplete twin pairs were excluded from the analyses. Separate thresholds were estimated for boys and girls and across cohorts, for both frequency and quantity. For quantity, the genetic correlation was estimated freely in the DOS group of the 1993 cohort.