

**Supplementary Table 1. Number of families before and after data screening**

Family Type	Initial	After screening <sup>a</sup>
MZ twin pairs	234	189
MZ twin pairs + sibling(s) <sup>b</sup>	82	54
DZ twin pairs	491	380
DZ twin pairs + sibling(s) <sup>b</sup>	95	72
Non-twin singletons/unpaired twins	150	320 <sup>c</sup>

46% of the sample had suffered a middle ear infection and it was included as a covariate in all analyses. 27% of the sample had a history of head injury but it had no effect on all intensity ratings and thus was not included (Hwang *et al.*, 2015).

<sup>a</sup> Participants were excluded if they scored water as moderate or higher taste (> 20 mm on gLMS), had large differences between presentation one and two and had overly high or low total average scores (Hansen *et al.* 2006; Hwang *et al.* 2015).

<sup>b</sup> Families with a twin pair and one or two siblings.

<sup>c</sup> The number of non-twin singletons/unpaired twins increases after cleaning as some twin pair families lose one twin during the screening procedure.

**Supplementary Table 2. Taste intensity characteristics of denatonium benzoate**

Mean $\pm$ SD <sup>a</sup>	79.5+24.8
Twin Correlations <sup>b</sup>	
$r_{MZ}$ (95% CI)	0.41 (0.3, 0.51)
$r_{DZ}$ (95% CI)	0.19 (0.1, 0.28)
Heritability (95% CI)	0.43 (0.33, 0.52)
Correlations (95% CI)	
Full Sample	
PROP	0.29 (0.25, 0.34)
SOA	0.63 (0.6, 0.66)
Quinine	0.58 (0.55, 0.61)
Caffeine	0.62 (0.59, 0.65)
gSweet	0.43 (0.4, 0.47)
<i>TAS2R38</i> adjusted <sup>c</sup>	
PROP	0.37 (0.33, 0.41)
SOA	0.63 (0.6, 0.66)
Quinine	0.6 (0.56, 0.63)
Caffeine	0.63 (0.6, 0.65)
gSweet	0.44 (0.4, 0.48)
AVI/AVI excluded <sup>d</sup>	
PROP	0.45 (0.4, 0.49)
SOA	0.62 (0.58, 0.65)
Quinine	0.57 (0.53, 0.61)
Caffeine	0.6 (0.56, 0.64)
gSweet	0.41 (0.36, 0.46)

Mean and standard deviation, MZ and DZ twin correlations, heritability estimate for perceived intensity ratings (millimeters on a labeled magnitude scale) of denatonium benzoate and phenotypic correlations with PROP, SOA, quinine, caffeine and a general sweetness factor (gSweet).

<sup>a</sup> n = 1882.

<sup>b</sup> 238 MZ and 446 DZ twin pairs. Estimates are from univariate AE models.

<sup>c</sup> *TAS2R38* diplotype, available for n = 1756, was tested in a partial dominant model.

<sup>d</sup> N reduced to 1229 when *TAS2R38* AVI/AVI diplotype excluded

**Supplementary Table 3.** Kurtosis and skewness of taste intensity ratings before and after square root transformation

	Kurtosis		Skewness	
	Original	Sqrt transformed	Original	Sqrt transformed
PROP	2.3963	1.9849	0.6164	-0.0931
SOA	2.5823	2.6556	0.3702	-0.1761
Quinine	2.8460	2.7351	0.5484	-0.1110
Caffeine	2.7097	2.5954	0.5125	-0.0202
Denatonium Benzoate	2.2380	3.2557	-0.4214	-0.8116
gSweet	5.0308	3.2773	1.1864	0.4587

The square root transformation approximates the intensity rating of gSweet to a normal distribution and does not worsen the distributions of those for PROP, SOA, quinine and caffeine.

**Supplementary Table 4.** Model fit of the Cholesky multivariate modelling for perceived intensity ratings of PROP, SOA, quinine, caffeine and gSweet

	Model	-2LL	df	AIC	$\Delta$ -2LL	$\Delta$ df	p
Full sample (n = 1901)	ACE	23236.74	9377	4482.743			
	<b>AE</b>	<b>23242.78</b>	<b>9392</b>	<b>4458.779</b>	<b>6.036</b>	<b>15</b>	<b>0.98</b>
	CE	23343.004	9392	4559.004	106.261	15	8.39E-16
<i>TAS2R38</i> adjusted <sup>a</sup> (n = 1756)	E	23676.959	9407	4862.959	440.216	30	1.96E-74
	ACE	20216.56	8661	2894.561			
	<b>AE</b>	<b>20225.1</b>	<b>8676</b>	<b>2873.103</b>	<b>8.542</b>	<b>15</b>	<b>0.9</b>
AVI/AVI excluded (n = 1229)	CE	20257.308	8676	2905.308	40.747	15	3.50E-04
	E	20428.84	8691	3046.84	212.279	30	2.44E-29
	ACE	14413.51	6047	2319.511			
	<b>AE</b>	<b>14424.27</b>	<b>6062</b>	<b>2300.269</b>	<b>10.758</b>	<b>15</b>	<b>0.77</b>
	CE	14462.502	6062	2905.308	48.991	15	1.76E-05
	E	14632.462	6077	2478.462	218.951	30	1.33E-30

Abbreviations: degrees of freedom (df); -2 times the log-likelihood (-2LL); Akaike's information criterion (AIC).

All models are fitted versus Cholesky full ACE model. Best models are shown in bold.

<sup>a</sup> *TAS2R38* diplotype was tested in a partial dominant model.

**Supplementary Table 5.** Absolute variance (95% confidence intervals) in perceived intensities of PROP, SOA, quinine, caffeine, and the general sweet intensity accounted for by each genetic (A) and environmental (E) factor in Cholesky AE model (See Figures 2 and 3 for standardized variance.)

**a. Full sample**

	A1	A2	A3	A4	A5
PROP	0.72 (0.64, 0.81)				
SOA	0.02 (0.01, 0.05)	<b>0.36 (0.27, 0.45)</b>			
Quinine	0.01 (0, 0.02)	<b>0.19 (0.11, 0.27)</b>	0.20 (0.13, 0.27)		
Caffeine	0.03 (0.01, 0.06)	<b>0.17 (0.10, 0.25)</b>	0.02 (0, 0.05)	0.12 (0.07, 0.17)	
gSweet	0.01 (0, 0.03)	<b>0.08 (0.03, 0.15)</b>	0.02 (0, 0.06)	0 (0, 0.02)	0.24 (0.16, 0.31)

	E1	E2	E3	E4	E5
PROP	0.27 (0.23, 0.32)				
SOA	0.09 (0.05, 0.15)	0.49 (0.42, 0.58)			
Quinine	0.12 (0.07, 0.18)	0.08 (0.05, 0.13)	0.38 (0.33, 0.45)		
Caffeine	0.08 (0.04, 0.14)	0.15 (0.1, 0.21)	0.06 (0.04, 0.10)	0.35 (0.30, 0.40)	
gSweet	0.06 (0.02, 0.11)	0.01 (0, 0.03)	0.02 (0.01, 0.05)	0.02 (0, 0.03)	0.49 (0.43, 0.57)

n = 1901. A2, shown in bold, is the only common genetic factor for gSweet and the bitter compounds SOA, quinine, caffeine.

**b. Adjusted for *TAS2R38* diplotype.**

	A1	A2	A3	A4	A5
PROP	<b>0.20 (0.15, 0.25)</b>				
SOA	<b>0.05 (0.01, 0.10)</b>	<b>0.34 (0.26, 0.43)</b>			
Quinine	<b>0.07 (0.02, 0.13)</b>	<b>0.14 (0.08, 0.22)</b>	0.16 (0.10, 0.22)		
Caffeine	<b>0.08 (0.03, 0.15)</b>	<b>0.13 (0.07, 0.20)</b>	0.01 (0, 0.04)	0.12 (0.07, 0.17)	
gSweet	<b>0.05 (0.01, 0.11)</b>	<b>0.06 (0.02, 0.12)</b>	0 (0, 0.03)	0 (0, 0.02)	0.24 (0.15, 0.32)

	E1	E2	E3	E4	E5
PROP	0.30 (0.26, 0.35)				
SOA	0.08 (0.04, 0.13)	0.49 (0.42, 0.57)			
Quinine	0.12 (0.07, 0.18)	0.08 (0.05, 0.13)	0.40 (0.34, 0.46)		
Caffeine	0.09 (0.05, 0.15)	0.14 (0.09, 0.20)	0.06 (0.03, 0.09)	0.34 (0.30, 0.39)	
gSweet	0.04 (0.02, 0.08)	0.01 (0, 0.04)	0.03 (0.01, 0.06)	0.01 (0, 0.04)	0.49 (0.43, 0.57)

n = 1756. The genetic variance in PROP reduces from 0.72 to 0.20 after adjustment whereas its environmental variance remains. The total genetic and total environmental variances in SOA, quinine, caffeine, and gSweet do not change after adjustment. Both A1 and A2, shown in bold, are common genetic factors for intensity ratings of sweet and bitter tastes. *TAS2R38* diplotype was tested in a partial dominant model.

**c. *TAS2R38* AVI/AVI excluded.**

	A1	A2	A3	A4	A5
PROP	<b>0.37 (0.31, 0.43)</b>				
SOA	<b>0.07 (0.03, 0.12)</b>	<b>0.31 (0.23, 0.39)</b>			
Quinine	<b>0.07 (0.03, 0.12)</b>	<b>0.14 (0.08, 0.22)</b>	0.16 (0.1, 0.23)		
Caffeine	<b>0.09 (0.05, 0.15)</b>	<b>0.09 (0.04, 0.15)</b>	0.01 (0, 0.05)	0.15 (0.10, 0.21)	
gSweet	<b>0.04 (0.01, 0.09)</b>	<b>0.08 (0.03, 0.15)</b>	0 (0, 0.03)	0 (0, 0.02)	0.27 (0.17, 0.36)

	E1	E2	E3	E4	E5
PROP	0.26 (0.22, 0.31)				
SOA	0.13 (0.08, 0.19)	0.46 (0.40, 0.53)			
Quinine	0.17 (0.11, 0.24)	0.05 (0.03, 0.09)	0.37 (0.32, 0.43)		
Caffeine	0.12 (0.07, 0.19)	0.14 (0.09, 0.19)	0.06 (0.03, 0.09)	0.33 (0.29, 0.39)	
gSweet	0.05 (0.02, 0.10)	0 (0, 0.02)	0.03 (0.01, 0.06)	0.01 (0, 0.04)	0.49 (0.42, 0.57)

n = 1229. Participants with *TAS2R38* AVI/AVI diplotypes were excluded. The genetic variance in PROP reduces from 0.72 to 0.37 after adjustment whereas its environmental variance remains. The total genetic and total environmental variances in SOA, quinine, caffeine, and gSweet do not change after adjustment. Both A1 and A2, shown in bold, are common genetic factors for intensity ratings of sweet and bitter tastes. Both A1 and A2, shown in bold, are common genetic factors for intensity ratings of sweet and bitter tastes.

**Supplementary Table 6.** Genetic variance accounted for by each genetic factor in the Cholesky AE models

		A1	A2	A3	A4	A5
Full Sample	PROP	100%				
	SOA	6.2% (1.9, 12.5)	93.8% (87.5, 98.2)			
	Quinine	1.4% (0, 5.2)	45.8% (31.3, 61.2)	52.8% (37.3, 67.7)		
	Caffeine	9.3% (3.4, 17.5)	49.0% (34.0, 64.5)	5.9% (0.5, 15.8)	35.8% (22.7, 49.8)	
	gSweet	3.2% (0.3, 8.7)	23.4% (10.3, 41.5)	4.4% (0, 15.8)	0.1% (0, 6.2)	68.9% (51.5, 83.3)
TAS2R38 Adjusted <sup>a</sup>	PROP	100%				
	SOA	12.3% (3.4, 24.5)	87.7% (75.5, 96.6)			
	Quinine	17.8% (6.7, 31.5)	39.3% (25.1, 55.6)	42.9% (27.7, 58.1)		
	Caffeine	23.5% (10.2, 39.9)	38.2% (23.6, 54)	3.1% (0, 11.6)	35.2% (22.4, 49.1)	
	gSweet	15.1% (4.7, 29.9)	16.4% (5.8, 32.2)	0.8% (0, 8.5)	0% (0, 0)	67.7% (49.9, 82.5)
AVI/AVI excluded	PROP	100%				
	SOA	17.7% (8.8, 28.1)	82.3% (71.9, 91.2)			
	Quinine	18.6% (9.6, 28.8)	38.1% (24.5, 54.1)	43.3% (27.8, 58.3)		
	Caffeine	26.7% (15.5, 39.6)	25.2% (13.1, 38.6)	4.2% (0, 13.9)	43.9% (31.5, 57.6)	
	gSweet	11.2% (4.1, 20.9)	20% (8.3, 37.3)	0.2% (0, 8.7)	0.3% (0, 6.2)	68.4% (47.0, 83.2)

<sup>a</sup> TAS2R38 diplotype was tested in a partial dominant model.

**Supplementary Table 7.** Standardized variance (95% confidence intervals) in perceived intensities of PROP, SOA, quinine, caffeine, and glucose or fructose accounted for by each genetic (A) and environmental (E) factor in Cholesky AE model adjusted for the TAS2R38 diplotype (see Figure 3a for comparison)

**a. Glucose**

	A1	A2	A3	A4	A5
PROP	40% (31, 49)				
SOA	5% (1, 11)	36% (27, 43)			
Quinine	7% (2, 13)	15% (9, 22)	16% (10, 22)		
Caffeine	8% (3, 15)	13% (7, 20)	1% (0, 4)	12% (7, 17)	
Glucose	4% (1, 9)	3% (1, 8)	0% (0, 3)	1% (0, 5)	26% (17, 34)
	E1	E2	E3	E4	E5
PROP	60% (51, 69)				
SOA	8% (4, 14)	51% (44, 59)			
Quinine	12% (7, 18)	9% (5, 13)	41% (35, 48)		
Caffeine	9% (5, 15)	14% (10, 21)	6% (3, 10)	35% (30, 40)	
gSweet	3% (1, 7)	2% (0, 5)	3% (1, 6)	1% (0, 3)	58% (50, 66)

n = 1756.

**b. Fructose**

	A1	A2	A3	A4	A5
PROP	40% (31, 49)				
SOA	5% (1, 11)	36% (27, 43)			
Quinine	7% (2, 13)	15% (9, 22)	16% (10, 22)		
Caffeine	8% (3, 15)	13% (7, 20)	1% (0, 4)	12% (7, 17)	
Fructose	4% (1, 10)	5% (1, 10)	1% (0, 5)	0% (0, 4)	25% (15, 33)
	E1	E2	E3	E4	E5
PROP	60% (51, 69)				
SOA	8% (5, 14)	51% (44, 59)			
Quinine	12% (7, 18)	9% (5, 13)	41% (35, 48)		
Caffeine	9% (5, 15)	15% (10, 21)	6% (3, 9)	35% (30, 40)	
Fructose	2% (1, 6)	1% (0, 2)	2% (0, 5)	1% (0, 4)	59% (51, 68)

n = 1756.

**Supplementary Table 8.** Phenotypic correlations between taste intensities and IQ, personality and emphasis scores estimated from bivariate ACE models

	IQ	Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness	Emphasis
PROP	-0.11*	0.04	0.02	-0.05	-0.07*	-0.03	-0.02
SOA	-0.15*	0.07*	0.03	-0.07**	-0.06**	-0.04	-0.02
Quinine	-0.14*	0.07*	0.05	-0.05	-0.04	-0.05	0
Caffeine	-0.13*	0.07*	0.02	-0.04	-0.06**	-0.04	-0.02
gSweet	-0.07*	0.05	0.02	0.00	-0.03	-0.05	0

n = 1244~1256. \*p < 0.05 before correction for multiple testing. +Insignificant after adjusting for IQ.

**Supplementary Table 9.** Standardized variance in five taste traits in Cholesky AE models adjusted for the *TAS2R38* diplotype and further adjusted for IQ, neuroticism, openness and agreeableness

**a. IQ**

	A1	A2	A3	A4	A5
PROP	38% (28, 46)				
SOA	8% (3, 15)	31% (22, 38)			
Quinine	3% (0, 8)	15% (8, 23)	16% (9, 23)		
Caffeine	9% (4, 17)	12% (6, 19)	2% (0, 6)	14% (9, 19)	
gSweet	11% (5, 19)	4% (1, 9)	2% (0, 9)	0% (0, 2)	21% (11, 29)
	E1	E2	E3	E4	E5
PROP	62% (54, 72)				
SOA	8% (4, 14)	53% (46, 62)			
Quinine	16% (11, 23)	8% (4, 12)	42% (36, 48)		
Caffeine	9% (5, 14)	14% (9, 19)	5% (3, 8)	35% (30, 41)	
gSweet	3% (1, 7)	2% (0, 5)	2% (0, 4)	2% (0, 5)	54% (46, 62)

n = 1282.

**b. Neuroticism**

	A1	A2	A3	A4	A5
PROP	37% (27, 46)				
SOA	7% (2, 13)	30% (22, 38)			
Quinine	4% (0, 9)	14% (8, 22)	16% (9, 23)		
Caffeine	9% (3, 16)	11% (5, 18)	1% (0, 5)	13% (8, 19)	
gSweet	9% (4, 17)	3% (0, 8)	2% (0, 8)	0% (0, 3)	22% (12, 30)
	E1	E2	E3	E4	E5
PROP	63% (54, 73)				
SOA	10% (5, 15)	54% (46, 62)			
Quinine	16% (10, 23)	8% (4, 12)	43% (37, 49)		
Caffeine	9% (5, 15)	15% (10, 21)	6% (3, 9)	36% (31, 42)	
gSweet	4% (1, 8)	3% (1, 7)	2% (0, 4)	3% (1, 6)	52% (45, 60)

n = 1277.

**c. Agreeableness**

	A1	A2	A3	A4	A5
PROP	38% (29, 47)				
SOA	7% (2, 13)	30% (21, 37)			
Quinine	4% (1, 9)	14% (7, 22)	16% (9, 23)		
Caffeine	9% (3, 16)	11% (5, 18)	1% (0, 5)	13% (8, 19)	
gSweet	9% (4, 17)	3% (0, 9)	2% (0, 8)	0% (0, 3)	22% (12, 30)
	E1	E2	E3	E4	E5
PROP	62% (53, 71)				
SOA	10% (5, 15)	54% (46, 62)			
Quinine	16% (10, 23)	8% (4, 12)	43% (37, 49)		
Caffeine	9% (5, 14)	15% (10, 21)	6% (3, 9)	36% (31, 42)	
gSweet	4% (1, 8)	3% (1, 7)	1% (0, 4)	3% (1, 6)	52% (45, 60)

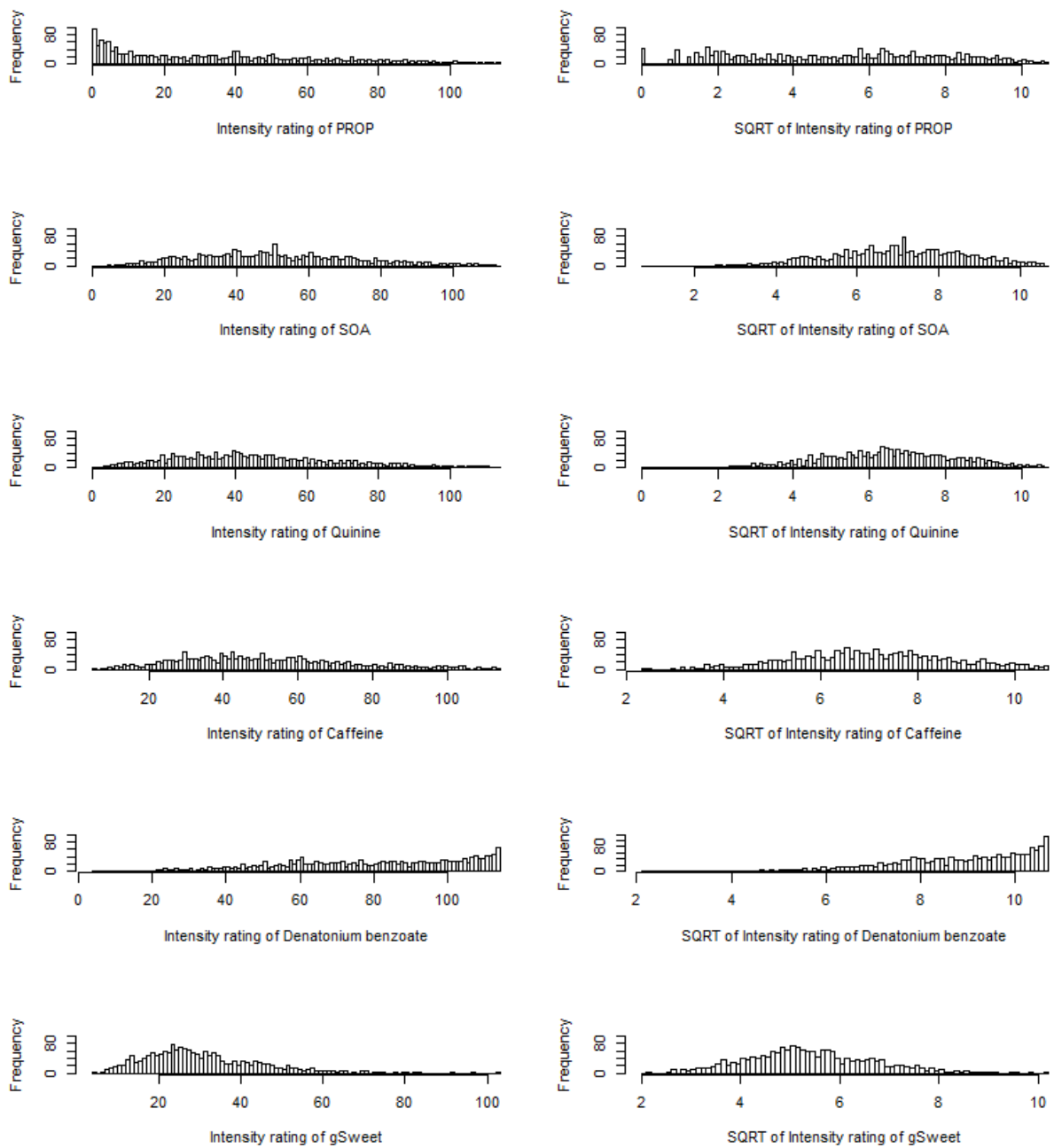
n = 1277.

The multivariate model adjusted for *TAS2R38* was used for comparison because it provided a better fit (AIC = 2873.103) than the model without adjustment (AIC = 4127.487) using the same sample (n = 1756).

**Supplementary Table 10.** Phenotypic correlations between PROP rating from one twin and ratings of SOA, quinine, caffeine, and gSweet from co-twin for MZ and DZ twins

	MZ	DZ
SOA	0.06 (-0.07, 0.18)	0.08 (-0.01, 0.17)
Quinine	0 (-0.12, 0.13)	0.03 (-0.07, 0.12)
Caffeine	0.09 (-0.04, 0.21)	0.11 (0.02, 0.20)
gSweet	0.10 (-0.03, 0.22)	0.10 (0, 0.19)

n = 1244~1256.



**Supplementary Figure 1.** Distribution of intensity ratings before and after square root transformation.