Data supplement to Arrondo et al. Hedonic and disgust taste perception in borderline personality disorder and depression. *Br J Psychiatry* doi: 10.1192/bjp.bp.114.150433

Online supplement

Previous literature on taste and major depressive disorder (MDD)

To the best of our knowledge seven previous published articles have studied if there are differences in the appraisal and/or recognition of taste stimuli between patients with depression and controls. We have included the main data from them in Table DS1.

The hypothesis behind these studies, namely that depression patients may perceive positive stimuli differently from the average population, is not new and studies date back as far as 1969. The number of participants has been small with clinical samples between 12 and 36 patients and control samples between 15 and 30 participants. The stimuli most typically evaluated are sucrose solutions (i.e. sweetness) and the sucrose concentrations have varied within a study, whereas specific works additionally studied the responses to bitter, sour, salty or citric stimuli. Regarding the measures obtained, most researchers have typically used either pleasantness or intensity ratings or threshold identification. The latter consists in participants indicating at which concentration they identify the presence of sucrose, hence obtaining an identification threshold in a typical psychophysical paradigm. The former measures are usually obtained by asking participants to indicate the pleasantness produced by the intake of the stimuli in a visual scale, or conversely, its intensity.

The first study in this manner evaluated the taste thresholds for different flavours in hospitalized patients and found that the recognition threshold in depression was heightened for all kinds of stimuli when compared to other psychiatric control patients. Moreover, they also found that the clinical symptoms correlated with this increased threshold and that recovery led to improvements in taste.[13] A study nearly 20 years later found increased intensity thresholds, but surprisingly increased pleasantness ratings in depression group when compared to normal controls.[14] Nevertheless this difference was not significant when only unipolar depression patients were considered. The subsequent studies were not been able to find differences in pleasantness ratings to positive stimuli between patients and controls.

See Table DS1 for a list of main relevant articles and a comparison of their most critical features.

Table DS1 Main relevant articles

Authorship	**Year**	**Depression group, *n***	**Health control group, *n***	**Measure**	**Flavours**
Dichter et al[18]	2010	12	15	Plesantness rating Intensity rating	Sweet
Swiecicki et al[2]	2009	21	30	Plesantness rating Threshold identification Flavour identification	Sweet Bitter Citric Sour
Berlin et al[15]	1998	20	20	Plesantness rating Threshold identification	Sweet
Potts et al[17]	1997	-*	-*	Threshold identification	Sweet
Steiner et al[16]	1993	21	16	Plesantness rating	**
Amsterdam et al[14]	1987	19	36	Plesantness rating Intensity rating	Sweet
Steiner et al[13]	1969	21	-	Threshold identification	Sweet Sour Salty Bitter

If the studies included other clinical samples these are not detailed in the table.

Measure is the type of measure carried out, whereas flavour is the different flavours used in the study.

* Samples were changed during the study

** Authors have not been able to access the original article

Participants

We used structured diagnostic interview schedules, the MINI (Mini-International Neuropsychiatric Interview) and SCID-II (Structured Clinical Interview for DSM-IV, part II) to establish the diagnoses required for inclusion and exclude volunteers who did not meet criteria. BPD patients were outpatients recruited via the Complex Cases Service (CCS), a specialized personality disorders unit; participants with unipolar depression by newspaper advertisements, and healthy participants from the Medical Research Council Cognition and Brain Sciences Unit healthy volunteer panel and also via advertisements. All participants were interviewed by a psychiatrist (the last author of this paper) with expertise in personality disorders. BPD patients with current or past history of any formally diagnosed psychotic illness or current major depressive disorder, or dependence on a psychoactive substance, as per the MINI, were excluded. The presence of depressive symptoms (as opposed to a full-blown, co-morbid major depressive illness) did not lead to exclusion. The presence of other personality disorder traits, but not that of the full-blown disorder, was permitted. In the MDD group, any comorbid psychiatric conditions as per the MINI or SCID led to exclusion, but the presence of personality disorder traits, without the full-blown disorder, was permitted. In healthy volunteers, any history or presence of psychiatric or neurological illness led to exclusion. No participant had any history of epilepsy, serious head injury, serious medical conditions, physical problems requiring hospitalisation, or surgery in general anaesthesia in the previous 6 months. Furthermore, all participants were tested during the follicular phase of their menstrual cycle (days 3-10) to eliminate the potential confounding factor of differential emotional responding due to hormonal differences.

Ethics statement: A local NHS research ethics committee approved this research (Cambridgeshire 4 Research Ethics Committee, NHS National Research Ethics Service, reference number: 09/H0305/10). Written informed consent was obtained from each participant.

The age of the different groups was 31.8 (SD 7.8) for the healthy controls, 35.3 (SD 7.8) for the BPD and 35.6 (SD 8.8) for the MDD group (mean and standard deviations are provided). When compared to the controls the MDD group was significantly different ($t=-2.13$ $p=0.038$) while BPD patients' age was also close to being significantly different compared to the health control (HC) group ($t=-1.87$ $p=0.069$). There were no differences between patient groups ($t=-0.91$ $p=0.928$). Nevertheless it must be noted that whether statistically significant or not, these differences do not seem to be of real clinical relevance as the overall range of ages was not wide. Moreover any differences found between the HC and only one of the patients' groups are unlikely to be explained by the age, since both patient groups had an older mean age than controls. This is especially so in the case that differences were found only in the BPD group (as is our case), in which the statistical significance of the differences was smaller than the in MDD group.

Participants were advised not to have any coffee, tea, or "energy drinks" such as "*Red Bull*" during the 2 hours previous to the evaluation and not to smoke in the previous hour. They were questioned regarding the fulfilment of this requirement prior to the experiment. Additionally participants were questioned to ensure that none had taken any psychoactive substances in the previous 24 hours.

On the choice of tastes and visual scales

Orange juice was chosen as a positive stimulus, quinine as a negative one and water as a neutral condition. While previous studies have typically used sucrose solutions for the evaluation of the pleasantness of positive stimuli, we decided to include orange juice as a more typical positive stimulus in everyday life.

Although we expected a high (inverse) correlation between the disgust and pleasantness ratings the rationale for the inclusion of two separate measures is that it was hypothesized that the former might be more sensitive to find differences in taste in the BPD group as the disorder is characterized by the alteration of a broad spectrum of disgust processes.

Taste evaluation

Studies lasted for approximately half an hour, with the questionnaire phase lasting 20 minutes and the taste evaluation 10 more minutes.

Stimuli were quinine dihydrochloride, orange juice and water. Concentration of quinine dihydrochloride was 0.006 mol/L solution and was prepared in the local pharmacy at a higher concentration and further diluted following the pharmacist's instructions at the research site for the experiment. Orange juice was obtained from a common brand of orange squash following the manufacturer's recommendation regarding dilution with water. Tap water was used for the quinine and juice dilutions as well as for the water flavour.

Ten mls from each stimulus liquid were put into closed blank plastic disposable cups for every participant. Cups were numbered for ease of randomization.

Evaluation of taste consisted in volunteers taking a sip, but not swallowing from a cup with 10 ml of orange juice (J), quinine dyhydrochloride at 0.006 mol/L (Q) or water (W). After putting the liquid in the mouth they had to maintain it there for 5 seconds (s) and then swallow or spit it out at their discretion. 30s later participants rated with a pen in two paper visual scales the pleasantness (20cm long, going from -10-very unpleasant- to 10 – very pleasant-) and disgust (10cm long, going from 0-not disgusting at all-, to 10-extremely disgusting) and finally rinsed their mouths with water after further 30s. There was at least a further 60s between flavour evaluations. Order of liquids was counterbalanced across subjects whereas clinical evaluation was completed prior to the taste experiment.

Prior to the taste evaluation participants held a clinical interview which included the Mini-international neuropsychiatric interview (MINI),[19] and completed several clinical measures and questionnaires.

Statistical analysis

Non-parametric tests were used throughout because of the ceiling effect of the visual scales and hence the non-normality of the obtained data. We used a Friedman ANOVA for repeated measures to evaluate whether there was an effect of condition (i.e. beverage) in the pleasantness and disgust ratings; we compared the three groups with a Kruskal-Wallis analysis and, as we were especially interested in differences between the two clinical groups and the control group these were compared through planned Mann-Whitney *U*-tests. Rho Spearman correlations were used to evaluate the association between taste disgust and disgust as rated by the two clinical rating scales, the SDS[6] and the DSR.[7] Statistical analyses were conducted with

SPSS21 (IBM; Armonk, NY, US) running on a Dell Optiplex789 with Windows XP. The threshold for significance was set at $p<0.05$ and tests were two-sided.

History of traumatization

There is some evidence linking history of psychological traumatization and abnormal disgust ratings both regarding self-disgust and also food or fluid-related disgust.[4,12] Since history of psychological trauma and post-traumatic stress disorder is more commonly seen in BPD patients than in the normal population it could be mediating the differences between groups. Subjects were divided into participants which had a history of trauma and those who did not, depending on answers to questions H1 and H2 (PTSD section) of the MINI questionnaire (H1: Have you ever experienced or witnessed or had to deal with an extremely traumatic event that included actual or threatened death or serious injury to you or someone else?; H2: Did you respond with intense fear, helplessness or horror?; participants answering affirmatively to both questions were considered to have a history of trauma). The number of participants with trauma history was 1, 0, and 9 for the HC, MDD and BPD group respectively. We then compared disgust and pleasantness ratings, as well as disgust scales, between the trauma and no trauma subgroups of the BPD participants in an exploratory analysis to see if trauma history could be influencing our results (See Table DS12). There were no differences in the disgust questionnaires between subgroups and similarly we did not find differences in the disgust ratings for quinine and juice, which were the measurements that differentiated BPD participants. On the other hand, BPD participants with traumatization history had increased disgust ratings for water and reduced pleasantness ratings when tasting quinine. Therefore, while history of trauma does not seem to be directly involved in the results found in this study, it is an important construct that should be controlled and evaluated in future studies,[4,11] ideally by use of a quantitative psychometric instrument.

Table DS2 Psychiatric medication

	BPD (N=17)	MDD (N=29)
Any medication	13 (76.5)	19 (65.5)
Any antidepressant	8 (47.1)	17 (58.6)
SSRI	5 (29.4)	15 (51.7)
Non SSRI antidepressants	4 (23.5)	4 (13.8)
Antipsychotic	3 (17.6)	0 (0)
Mood stabilizers	3 (17.6)	0 (0)
Benzodiazepines	5 (29.4)	0 (0)

BPD is Borderline Personality Disorder and MDD is Major Depressive Disorder. Number of patients in each clinical group (with percentage in brackets) taking a given class of medications. Healthy controls did not take any psychiatric medication per inclusion criteria.

Table DS3 Clinical scales

	HC	BPD	MDD
SDS	21 (16.25-25)	61 (52.5-69)	42 (37.5-50.5)
DSR	10.5 (6.75-12.5)	15 (13-20)	13 (8.5-16)
BDI	1 (0-3)	24 (9-34.5)	19 (13-26)
HRSD	0 (0-1)	15 (5-16)	21.5 (18.75-27)

SDS is Self-Disgust Scale,[6] DSR is Disgust Scale Revised,[7,20] BDI is the Beck Depression Inventory-II;[21] and HRSD is the Hamilton Rating Scale for Depression Scale.[22] Median with interquartile ranges (in brackets) are given. HC is Healthy Controls, BPD Borderline Personality Disorder and MDD is Major Depressive Disorder.

Table DS4 Correlation between pleasantness and disgust

	Juice	Water	Quinine
Rho	-0.261	-0.434	-0.803
p-value	0.026	<0.001	<0.001

Spearman correlations between pleasantness and disgust scales in the whole group of participants.

Table DS5 Effect of condition on pleasantness (Friedmann ANOVA)

	TS	SE	Std TS	p-value	Adj. p-value
Friedmann Anova	116.561	-	-	<0.001	-
J vs W	0.664	0.166	4.014	<0.001	<0.001
Q vs W	-1.096	0.166	6.621	<0.001	<0.001
Q vs J	-1.760	0.166	10.635	<0.001	<0.001

TS is the Test Statistic (Chi-Square for Friedman Anova, and W Wilcoxon for the post-hoc comparisons), SE is standard Error, Std TS is the standardized Test Statistic, Adj p-value is the adjusted significance for multiple comparisons (Dunn-Bonferroni procedure[23]). J is juice, W is water, and Q is quinine.

Table DS6 Effect of condition on disgust (Friedman ANOVA)

	TS	SE	Std TS	p-value	Adj. p-value
Friedmann Anova	111.85	-	-	<0.001	-
J vs W	-0.116	0.166	-0.703	-0.482	1
Q vs W	1.349	0.166	-8.152	<0.001	<0.001
Q vs J	-1.466	0.166	-8.855	<0.001	<0.001

TS is the Test Statistic (Chi-Square for Friedman Anova, and W Wilcoxon for the post-hoc comparisons), SE is standard Error, Std TS is the standardized Test Statistic, Adj p-value is the adjusted significance for multiple comparisons (Dunn-Bonferroni procedure[23]). J is juice, W is water, and Q is quinine.

Table DS7 Effect of group on ratings (Kruskal-Wallis test)

Liquid	Measure	TS	p-value
Juice	**Pleasantness**	5.30	0.070
	Disgust	5.24	0.073
Water	**Pleasantness**	2.62	0.269
	Disgust	0.66	0.719
Quinine	**Pleasantness**	6.53	0.038
	Disgust	8.26	0.016

TS is the Test Statistic (Kruskal-Wallis H)

Table DS8 Effect of group on pleasantness (Mann-Whitney U tests)

	WG	HC	BPD	MDD	BPD vs HC	MDD vs HC
Juice	4 (1.5 — 6.1)	4.3(3.1—6.9)	2.1 (-0.6 — 5)	3.8 (1.4 — 5.9)	135 (SE=41.47; p=0.023)	311.5 (SE=60.97; p=0.189)
Water	0 (-0.1 —0.1)	0 (-0.4 — 0)	0 (-1 — 0)	0 (0 —1.4)	212 (SE=38.81; p=0.652)	466 (SE=57.85; p=0.198)
Quinine	-8 (-9.6 — -6)	-7.1 (-8.2 — -5.4)	-9.5 (-10 — -7.4)	-7.9 (-9.5 — -6.1)	129.5 (SE=41.29; p=0.015)	326.5 (SE=60.90; p=0.286)

WG is Whole Group, HC Healthy Controls, BPD Borderline Personality Disorder and MDD is Major Depressive Disorder. In 4 first columns median with interquartile ranges (in brackets) are given. Last 2 columns are U Mann Whitney results, test standard error (SE) and its associated p value.

Table DS9 Effect of group on disgust (Mann-Whitney U tests)

	WG	HC	BPD	MDD	BPD vs HC	MDD vs HC
Juice	0(0—0.1)	0 (0—0)	0 (0—1.4)	0 (0—0.1)	305.5 (SE=34.28; p=0.027)	434 (SE=47.50; p=0.371)
Water	0 (0—0.5)	0 (0—0.6)	0.1 (0—1.3)	0 (0—0.45)	253 (SE=38.4; p=0.612)	380 (SE=55.55; p=0.836)
Quinine	7.5 (4.1-9.3)	6.2 (3—8.1)	9 (6.9—10)	7.4 (4.7—9.3)	342 (SE=41.4; p=0.007)	491 (SE=60.95; p=0.103)

WG is Whole Group, HC Healthy Controls, BPD Borderline Personality Disorder and MDD is Major Depressive Disorder. In 4 first columns median with interquartile ranges (in brackets) are given. Last 2 columns are U Mann Whitney results, test standard error (SE) and its associated p value.

Table DS10 Correlations between disgust scales and disgust ratings in BPD (Spearmann)

	Juice		Water		Quinine	
	Rho	**p-value**	**Rho**	**p-value**	**Rho**	**p-value**
SDS	0.501	0.037	0.111	0.670	0.295	0.251
DSR	0.151	0.562	-0.101	0.701	-0.006	0.982

SDS is Self-Disgust Scale[6], DSR is Disgust Scale Revised.[7,20] J is juice, W is water and Q is quinine. Rho is the Spearmann correlation.

Table DS11 Correlations between disgust scales and disgust ratings in MDD (Spearmann)

	Juice		Water		Quinine	
	Rho	**p-value**	**Rho**	**p-value**	**Rho**	**p-value**
SDS	0.131	0.498	-0.104	0.590	-0.003	0.988
DSR	0.112	0.563	-0.262	0.170	-0.181	0.347

SDS is Self-Disgust Scale,[6] DSR is Disgust Scale Revised[7,20] J is juice, W is water and Q is quinine. Rho is the Spearmann correlation.

Table DS12 Effects of traumatization in the BPD group(Mann-Whitney U tests)

	No trauma	**Trauma**	**Trauma vs. No trauma**
Juice pleasantness	2.5 (-1.2 – 8.2)	1.5 (-2.9 – 5.0)	26.5 (SE = 9.43; p = 0.606)
Juice disgust	0.6 (0.0 – 2.0)	0.0 (0.0 – 2.7)	24.5 (SE = 8.84; p = 0.470)
Water pleasantness	-0.8 (-5.2 – 0.0)	0.0 (0.0 - 0.0)	45.0 (SE = 8.57; p = 0.174)
Water disgust	0.50 (0.1 – 4.1)	0.0 (0.0 - 0.35)	8.0 (SE = 9.04; p = 0.012)
Quinine pleasantness	-8.7 (-9.2 – 6.7)	-10 (-10 – -9.5)	11.5 (SE = 9.19; p = 0.031)
Quinine disgust	8.5 (6.1 – 9.2)	10 (6.95 – 10)	44.5 (SE = (9.20; p = 0.174)
SDS	66 (54 – 76)	61 (54.5 – 69.5)	27.5 (SE = 9.43; p = 0.681)
DSR	16 (14 – 20)	15 (10.75 – 20)	22.0 (SE = 9.42; p = 0.351)

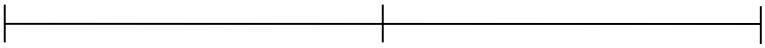
SDS is Self-Disgust Scale,[6] DSR is Disgust Scale Revised.[7,20] In first two columns median with interquartile ranges (in brackets) are given. Last column includes U Mann Whitney results, test standard error (SE) and its associated p value.

TASTE TASK

Participant code:_____ Date:_____

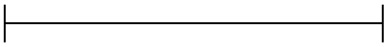
CUP 1

Pleasantness



-10 (very unpleasant) (very pleasant) **+10**

Disgust



0 (not disgusting at all) (extremely disgusting) **+10**

Figure DS1: Visual scales: Response sheet provided to the participants. After taking a sip out of a cup filled with 10 ml. of liquid and maintaining the liquid in their mouths for 10 seconds they had to rate the pleasantness and disgust produced by the intake of the beverage. Pleasantness line measured 20 cm whereas the disgust line measured 10 cm.

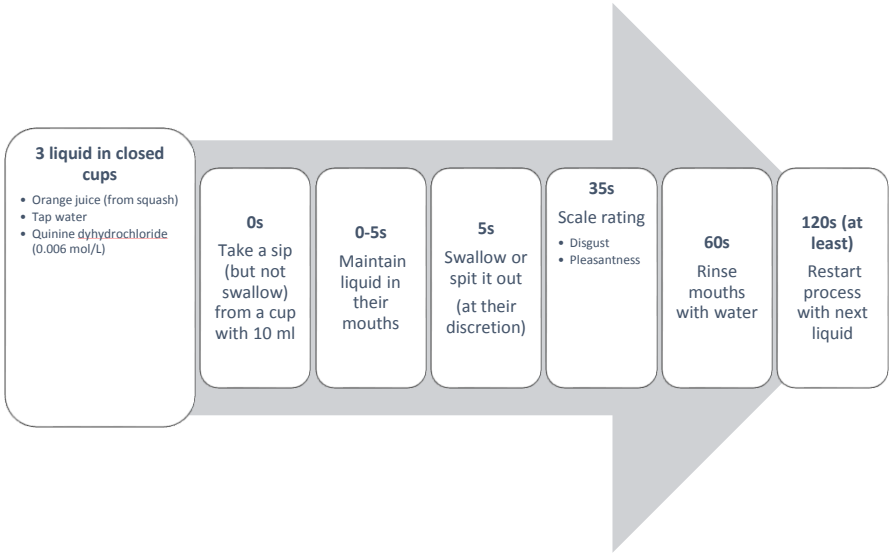


Figure DS2 Flow diagram of taste evaluation

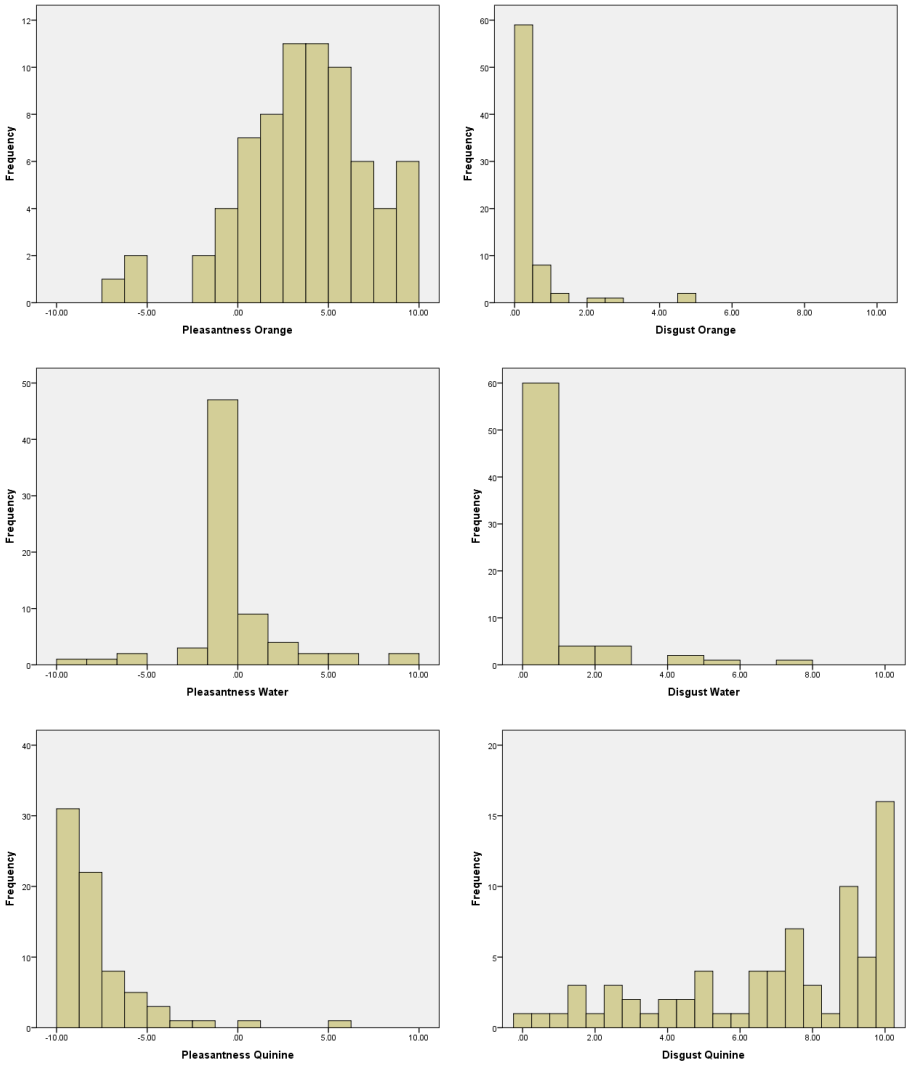


Figure DS3 Whole group pleasantness and disgust ratings. The left column shows the histograms of the pleasantness ratings for the 3 conditions in the whole group of participants. The right column shows the histograms of the disgust ratings for the 3 conditions in the whole group of participants.

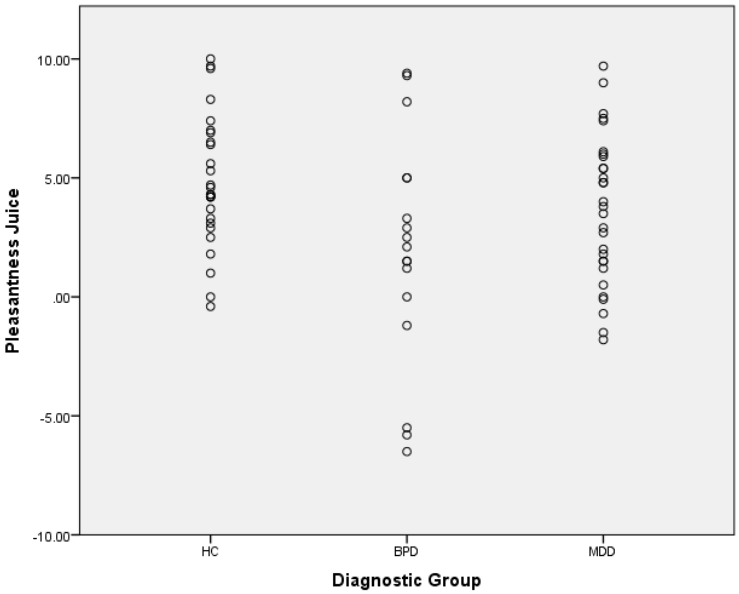


Figure DS4 Scatter plot with juice pleasantness ratings.

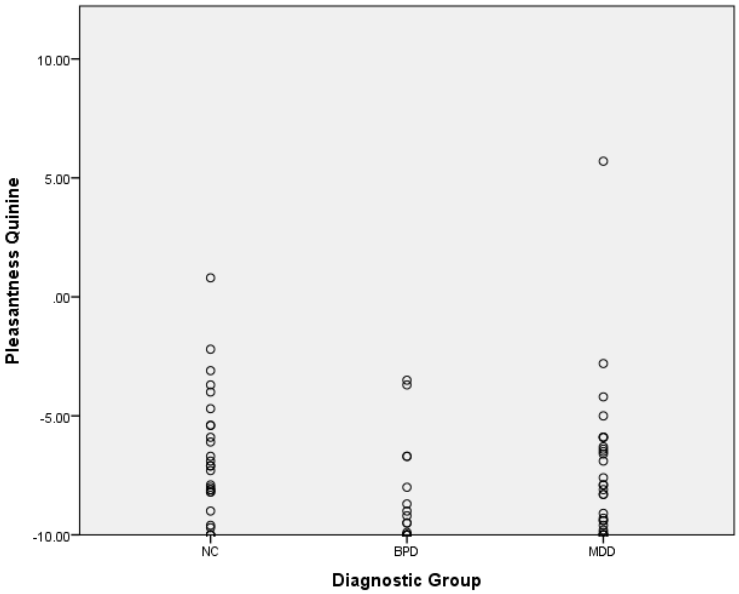


Figure DS5 Scatter plot with quinine pleasantness ratings

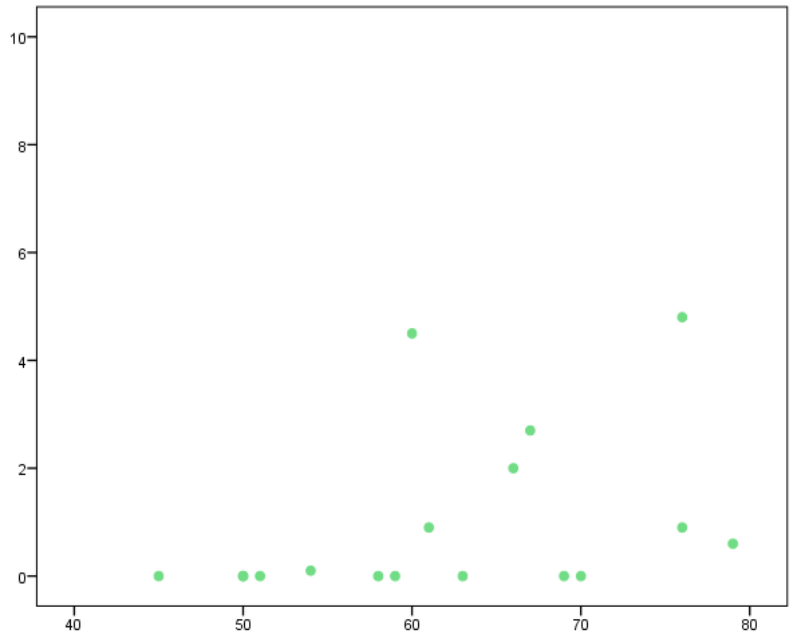


Figure DS6 Scatter plot of the disgust ratings for Juice (Y axis) and the Self-Disgust Scale results (X axis) in the Borderline Personality Disorder group.

Additional references

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