of the nets. Thus, wanderings of nonterritorial supertramps are unlikely to have significantly inflated the mist-net yields. Predators of birds are more diverse and far more abundant on Long than on control islands, so that supertramp abundance cannot be attributed to reduced predation pressure.
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Factors of Human Chronic Pain: An Analysis of Personality and Pain Reaction Variables

Abstract. *Factor analysis of pain and personality test data obtained from 119 patients with chronic pain syndromes yields seven factors: four composed of personality measures, two involving different psychophysical pain measures, and one sex-related factor. The chief factors, comprising more than 50 percent of the total variance, are "interpersonal alienation and manipulativeness," "clinical pain intensity," and "pain endurance."*

Although there is an impressive body of evidence to show that personality variables influence pain behavior (*1*), this has been more easily demonstrated in the laboratory than in the clinical situation. The difficulty in establishing precise relations among pain and personality variables in patients has been that of quantifying the intensity of the clinical (that is, not experimental) pain experienced. In this report we give the results of an analysis in which several measures of clinical pain are intercorrelated with personality measures.

Our subjects were 119 consecutive (unselected) patients for whom complete data were available (11 additional patients in the series had incomplete data and were not included in the analyses). The patients were seen as part of the evaluation procedure for admission to the inpatient Pain Unit of this hospital or on consultation at two community hospitals. All patients had chronic pain (more than 6 months duration) that had not been adequately controlled by conventional means. In all but two patients the pain was "benign," that is, not associated with terminal disease, and in all but 18 there were adequate physical findings to account for the pain complaint; these 18 patients had complaints of headache or low back pain without significant findings. The other pain syndromes were associated with cervical and lumbar disk syndromes, degenerative arthritis of the spine (but not rheumatoid arthritis), thalamic pain, causalgia, brachial plexus avulsions, trigeminal neuralgia, and so forth.

Table 1. Values for factored variables.

Variable	Average value	Standard deviation
Tourniquet test		
Clinical pain level	3.25 minutes	3.50 minutes
Maximum pain tolerance	6.75 minutes	4.83 minutes
Ratio, $\left(\frac{\text{clinical}}{\text{maximum}} \times 100\right)$	46	28
Difference (maximum − clinical)	3.50 minutes	3.50 minutes
Pain estimate − ratio	10	25.6
Pain estimate (0 = no pain, 100 = worst possible)	57	19
Health Index		
Invalidism	2.9	2.4
Manifest depression	7.7	4.3
Pain preoccupation	5.2	1.8
Pain games	3.7	2.2
Total	19.5	8.4
MMPI		
Hs (hypochondriasis)	75	13
D (depression)	72	16
Hy (hysteria)	74	10
Pd (psychopathic deviate)	64	13
Mf (masculinity-femininity)	56	11
Pa (paranoia)	57	9
Pt (psychasthenia)	63	14
Sc (schizophrenia)	64	15
Ma (hypomania)	60	11
Si (social introversion)	52	9
Age	45.7 years	12.6 years

Patients completed a Minnesota Multiphasic Personality Inventory (MMPI), a short Health Index (*2*), gave a pain estimate in which they rated the average intensity of their pain on a scale from 0 to 100, and took a tourniquet pain test (*3*). The latter produces arm ischemic pain and is our adaptation of the submaximum effort tourniquet technique (*4*). It yields two direct measures: the time at which the average clinical pain is matched in severity (clinical pain level), and the time to reach the unbearable level of pain (maximum pain tolerance).

Twenty-three variables were collected from each patient for factor analysis. These included the ten clinical scales of the MMPI, the four scales of the Health Index, the pain estimate, and the clinical pain level and maximum pain tolerance of the tourniquet pain test. Four derived variables were computed: the difference between the clinical pain level and the maximum pain tolerance; the ratio of the clinical pain level to the maximum pain tolerance, computed by dividing the maximum pain tolerance value into the clinical pain level, and multiplying the quotient by 100; the difference between the pain estimate and the ratio just described; and the total of the four Health Index scales. The final two variables were age and sex.

The data were intercorrelated, forming a 23 by 23 matrix which was subjected to a factor analysis by using the principal components method with unities in the main diagonal. Seven factors were extracted with eigenvalues greater than 1, and these factors were rotated by means of the oblique rotation method, in which the obliqueness control was set to zero. The program used in this analysis is a part of a computer data analysis package of social sciences programs (*5*).

Of the patients, 81 were males and 38 were females; values for all the other variables are presented in Table 1. These data show that the neurotic scales of the MMPI [hypochondriasis (Hs), depression (D), and hysteria (Hy)] are elevated in a psychophysiological pattern which is characteristic of patients with chronic disease; the character disorder [psychopathic deviate (Pd) and masculinity-femininity (Mf)] and psychotic scales [paranoia (Pa), psychasthenia (Pt), schizophrenia (Sc), and hypomania (Ma)] are within normal limits. The neurotic scales, however, although having elevated mean values which might differentiate this group from some other, do not contribute greatly to the factor analysis, which is based on the variance of the scores rather than the mean values.

The factor loadings after rotation of the first seven factors are presented in Table 2. The variables loading most heavily on factor 1 are the scales of the MMPI, which at the higher values are involved in either character disorder or psychotic behavior patterns—Pa, Pd, Sc, and Ma, in addition to age.

On the basis of the average scores for these scales in our data, such a combination of scales indicates an externalization of responsibility and placing the blame for current problems on someone else, anger and hostility directed outward, interpersonal conflicts, and an alienation or feeling different from others. Considering that the only apparent similarity among the patients is the state of chronic pain and physical disability, it is striking that this first factor to emerge consists of those scales of the MMPI which, taken together, suggest a feeling of being out of control of one's life, suspicion and anger toward others, blaming others for one's difficulties, and attempts to manipulate and control others. We designate this an *interpersonal alienation and manipulativeness factor* to suggest that some patients with chronic pain (or disability, or both), who feel different and helpless, may engage in special attempts to influence others. This finding supports clinical descriptions of "pain games" and "painmanship" (*6*).

Factor 2 is clearly a pain factor involving a sense of average level of clinical pain. The ratio between the clinical and maximum pain levels is the variable loading most highly on this factor, and it is the pain measure that probably most closely approximates the patient's actual pain perception since it results from stimulus matching (*3*). The next variable loading on factor 2 is the difference between the pain estimate and the ratio. The pain estimate is consistently higher than the ratio and the difference between them is significant (t-test for paired scores yielding a $t = 4.450$, d.f. $= 118$, $P < .001$). The pain estimate does not load on this factor at all. As the heaviest loadings are from the more accurate matching of the clinical pain on the tourniquet test and the derived ratio score variables, we term this the *clinical pain intensity factor*. The failure of the pain estimate to load on this factor, as well as the significant difference between it and the tourniquet pain ratio, supports our contention that the two are quite different measures and that the difference between the subjective estimate and the psychophysical ratio may indicate some communicative need on the part of the patient concerning his pain (*3*).

Table 2. Rotated factor loadings. Values are the loadings of each variable on each factor.

Variable	Factors						
	1	2	3	4	5	6	7
Tourniquet test							
Clinical pain level	.01	.76	.50	.18	−.07	.10	.10
Maximum pain tolerance	−.01	.23	.95	.06	−.04	.03	.14
Ratio	−.02	.91	−.17	.11	−.13	.04	.01
Difference	−.03	−.44	.82	−.10	.02	−.07	.09
Pain estimate	−.02	.13	−.22	.47	−.40	.26	.14
Pain estimate − ratio	.00	−.92	.03	.22	−.15	.15	.10
Health Index							
Invalidism	.06	.02	.03	−.00	−.73	.25	.14
Manifest depression	.10	.06	−.18	−.23	−.70	−.01	.09
Pain preoccupation	−.15	−.07	−.08	.19	−.73	−.20	.20
Pain games	.07	.03	.25	−.15	−.78	−.12	−.39
Total score	.06	.03	−.03	−.12	−.94	−.01	.03
MMPI							
Hs	.13	−.08	.13	.03	−.05	−.18	.80
D	.17	.12	.02	−.53	−.27	−.21	.40
Hy	.21	−.01	.21	.01	−.06	.01	.78
Pd	.70	.01	−.03	.09	−.10	−.08	.22
Mf	.05	.04	−.04	.03	−.09	−.77	.06
Pa	.75	.03	−.08	−.15	.02	.08	.15
Pt	.48	.02	−.07	−.04	−.25	−.15	.32
Sc	.69	−.07	−.10	−.21	−.10	−.06	.33
Ma	.58	−.06	−.07	.47	−.14	−.30	−.18
Si	.03	−.01	−.08	−.81	−.22	.08	−.08
Sex	−.09	.04	.03	.02	.08	−.91	.03
Age	−.67	−.12	−.24	−.12	−.11	−.04	.31
Percent of variance	27.8	13.2	10.5	7.5	7.0	6.3	5.4
Cumulative percent	27.8	41.0	51.5	59.0	66.0	72.3	77.7

Factor 3 is another pain factor, but the variables that load highly on it are those which measure the patient's maximum pain tolerance. The two variables are the maximum pain tolerance indicated by the tourniquet pain test and the difference between the maximum pain tolerance and the clinical pain level. A pain variable referred to as the pain sensitivity range (PSR) has been described, which is computed as the difference between the pain threshold (first sensation of pain) and the maximum pain tolerance. This PSR, across several body loci and types of pain tests, comprises a specific pain endurance factor (*7*). Because of the nature of the tourniquet pain test, in which subjects experience a certain amount of pain before the point of measurement is reached, our closest approximation of the PSR is the difference between the maximum pain tolerance and the clinical pain level. This and the maximum pain tolerance itself are the major loadings on factor 3, and so indirectly support the concept of a *pain endurance factor*.

The first three factors account for more than 50 percent of the variance of the data, and, although the remaining factors may be discriminating between groups, they do not account for much of the variance in this analysis (*8*).

In sum, our data show that when quantified pain measures and personality variables are obtained from a population of patients with chronic pain, a significant proportion of the variance is contributed by variables comprising a factor of *interpersonal alienation and manipulativeness*. This implies that, for some patients, attempts at rehabilitation must be directed not merely toward the palliation of the pain state itself, but at social integration and self-control as well.

GRETCHEN TIMMERMANS
Pain Unit, Veterans Administration Hospital, San Diego, California 92161
RICHARD A. STERNBACH
Department of Psychiatry, University of California, San Diego, La Jolla 92037, and *Pain Unit, Veterans Administration Hospital, San Diego*

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8. Factor 4 includes the highest pain estimate loadings, is associated with the social introversion scale of the MMPI with scores in the direction of extraversion, and to a lesser extent with the depression scale. It is thus clearly a *pain complaint factor* [see M. R. Bond, *Br. J. Psychiat.* **119**, 671 (1971)]. Factor 5 is specific to the scores on the Health Index, factor 6 is a sex-related factor, and factor 7 is a general neuroticism factor from the MMPI scales.
9. We thank Dr. Lowell H. Storms for his helpful comments and suggestions.

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Gravity Anomalies in the Galápagos Islands Area

In a recent report Case *et al.* (*1*) presented a free-air gravity anomaly map of the Galápagos Islands based on 32 gravity stations on the islands. On the basis of their data they stated that the Galápagos Islands are associated with an east-west trending "residual negative anomaly" which is superimposed on a "broader positive anomaly of unknown amplitude and extent." They concluded that "the gravity data can be most readily interpreted in terms of a low-density region related to a hot spot or plume" beneath the islands.

We believe, however, that the data of Case *et al.* in no way support this interpretation. Their observations can, in fact, be explained simply if the Galápagos Islands are in some form of isostatic equilibrium. Any form of isostatic compensation will result in an "edge effect" in the free-air anomaly at the location of a large change in relief. For a relatively narrow feature, the edge effect anomalies over the two "edges" merge, resulting in a large positive anomaly. For a wider feature, the two edge effects become separated, resulting in an area of less positive anomalies over the center of the feature.

The major difficulty with the interpretation of Case *et al.* is that they did not quantitatively consider that the observed gravity anomalies could arise, at least in part, from the topography of the islands and its compensation.

A number of studies (*2*, *3*) have shown that gravity anomalies in the vicinity of volcanic islands can be in large part explained by a downwarping model in which the strong outer layer of the earth (lithosphere) is treated as a loaded elastic beam (or plate) overlying a weak fluid substratum (asthenosphere). This model has also been used in studies of the deformation of the lithosphere due to ice sheets (*4*) and sediments (*5*).

We show (Fig. 1) a north-south profile across the Galápagos platform at longitude 90°30′W and the deformation which would result if the platform represents a two-dimensional load on a lithosphere treated as an elastic beam overlying a weak fluid. The topography is taken from the bathymetry maps of Chase (*6*), and the effective flexural rigidity assumed in the computations is 1.0×10^{30} dyne-cm. This value is similar to generally accepted values obtained in other studies (*3*–*5*).

We also show the gravity effect of the deformation model in Fig. 1. The undeformed crustal structure, assumed in computing the gravity anomalies, is representative of the mean crustal structure of the Pacific basins deduced by Shor *et al.* (*7*). The model results in large positive anomalies over the Galápagos platform with amplitudes of about 80 mgal over the outer islands of Floreana and Marchena and about 45 mgal near the islands of San Salvador and Santa Cruz. There are also large negative anomalies associated with the edge of the platform and the trough between Marchena and San Salvador.

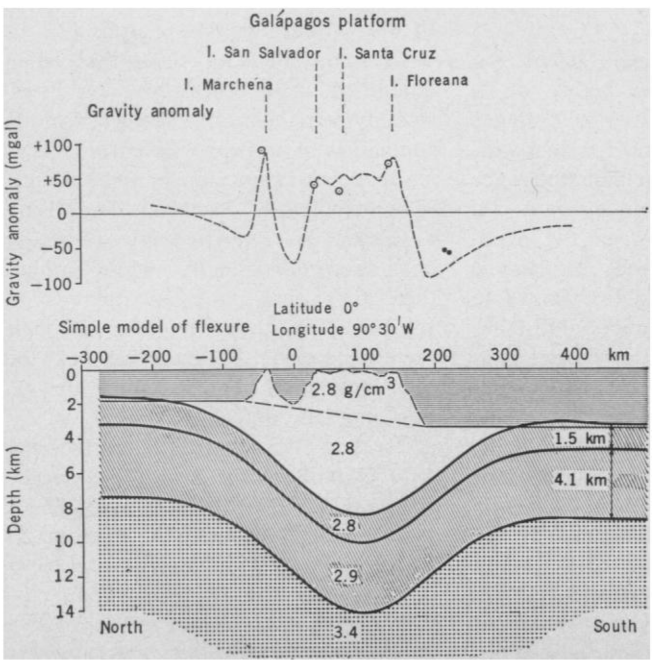

Fig. 1. Comparison of observed free-air gravity anomalies (data points) in the vicinity of the Galápagos platform with the computed gravity effect (dashed line) of a simple model of deformation due to the load of the platform. Observed gravity data are from (⊙) Case *et al.* (*1*) and (●) the R.V. *Vema* (unpublished data); bathymetric contours are from Chase (*6*). The gravity effect of the simple model predicts less positive anomalies over the center than over the edges of the platform.

We have included in Fig. 1 observed free-air anomalies obtained from Case *et al.* (*1*) and from the R.V. *Vema* which are located within 5 km of the profile. The computed curve is in good agreement with the observed values. It is of particular interest that the crustal deformation model predicts a decrease of about 40 mgal between the gravity anomalies measured on the outer and inner islands. The predicted decrease occurs in the region of the residual negative anomaly of Case *et al.* The decrease in the amplitude of the positive anomalies toward the center of the platform is, in fact, characteristic of wide loads. It arises because the deformation, and therefore its negative gravity contribution, increases toward the center of the load, while the positive gravity effect of the load has a nearly constant value over that region. In contrast, relatively narrow loads, such as islands comprising the Hawaiian