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edited by

David Canter
Department of Psychology,
University of Surrey, U.K.

Jorge Correia Jesuino
Instituto Superior de Ciencias,
do Trabalho e da Empresa
Lisbon, Portugal

Luís Soczka
Laboratório Nacional de Engenharia Civil,
Lisbon, Portugal

and

Geoffrey M. Stephenson
Institute of Social and Applied Psychology,
University of Kent at Canterbury, U.K.

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3 The bus-stop
One afternoon you are standing at the bus-stop nearest home, when a group of 15 or 16 year old boys comes along. They begin kicking the bus-stop and writing graffiti on the bus shelter.

4 The car
Late one evening you go to put the dustbin out. A short way up the street you see two men walking around a parked car. When they see you looking at them, they begin to walk towards you.

5 To a party
You have been invited to a party in a neighbourhood you don't really know. Early that evening you set out by bus. When you get off you still have a long way to walk. Suddenly you notice that you have lost the way.

6 The cafe
You're travelling through a town where you've never been before. You have to ring home to say you'll be late getting back. Because you can't find a telephone box, you go into a cafe to ring from there. It turns out to be where a group of bikers meet.

EFFECTS OF WEATHER AND AIR POLLUTION ON MOOD : AN INDIVIDUAL DIFFERENCE APPROACH

HERMANN BRANDSTÄTTER, MARTIN FRÜHWIRTH & ERICH KIRCHLER
University of Linz, Austria

Abstract

Within a time sampling study of the effects on unemployment of subjective well-being (Kirchler, 1985) 14 men and 12 women recorded their mood several times a day over a period of 40 days according to the time sampling diary of Brandstätter (1977). For the present study each subject's sensitivity to air pollution and weather changes has been assessed by calculating the multiple regression (auto-regressive model) of his/her time series of mood scores on the time series of air pollution and weather indicators (SO_2, dust, temperature, steam pressure, visibility, cloudiness, wind speed, precipitation, barometric pressure). The standard partial regression coefficients were conceived of as indicators of a subject's sensitivity to weather changes and used as dependent variables in ANOVAs with emotional stability (low-high) and extroversion (low-high) as factors. The sensitivity to air pollution, temperature, steam pressure, wind speed, precipitation and barometric pressure turned out to be partly interaction effects, partly main effects of emotional stability and extroversion. Only interdisciplinary cooperation in studying the physiological and psychological processes causing the influence of weather on mood can lead to appropriate theoretical explanations of the observed effects.

Introduction

People like talking about the weather, a favoured topic to begin a conversation with a stranger or casual acquaintance. It is easy to agree that it is too hot or too cold, too dry or too wet, occasionally that one can really enjoy it just as it is. When meeting with friends and relatives, people also seem quite often to talk about the weather, this time blaming it for a headache, fatigue, or ill temper.

Many people (up to 70% of survey samples; Faust 1977, p 61) are convinced that the weather has some impact on their well-being, but how can we be sure that they don't just express a stereotype (inferring a certain mood state from a certain type of weather) or blame the weather as cause for their health problems or emotional discomfort which actually may have other causes unknown to them?

On the collective level, there is ample evidence that the incidence of health problems, psychosomatic grievances, violence, and suicide is in some way tied to changing weather conditions (Baron & Ransberger, 1978; Belek & Klein, 1983; Charry & Hawkinshire, 1981; Faust, 1977; Muecher & Ungeheuer, 1961; Rotton & Frey, 1985; Rotton et al, 1979). No doubt the weather has some real disturbing effects on some of the people.

Gensler (1973; quoted by Faust, 1977, p 77f) performed a study with a personality inventory (FPI; Freiburger Persönlichkeitsinventar) and a checklist of self-reported sensitivity to weather changes ("Wetterfühligkeit") and found weather sensitivity related to several subscales of neuroticism. People who describe themselves as nervous, depressed,

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excitable, tense, and restrained, report also many symptoms of weather sensitivity. However, this could be, at least in part, a reflection of a person's general negative affectivity (Watson & Clark, 1984). That people who perceive themselves as sensitive to weather conditions actually differ in some measures of a standard blood test has been shown by Jenkner (1983). This means that self-reported weather sensitivity has at least something to do with body functions. Nevertheless, whether high neuroticism really predisposes people to fluctuations of psychosomatic well-being depending on the weather conditions needs a more direct test. What we need are longitudinal studies on the individual level with a method allowing causal inferences less contaminated by the subjects' prejudices and misattributions than common interviews and questionnaires (cf Evans & Jacobs, 1981, for questionnaire studies on air pollution).

There are a few time series studies on weather and mood which take individual differences into account. Unfortunately, Goldstein's (1972) brief report on individual differences in time series dependence of semantic differential mood scores (evaluation, activity, and potency) on weather variables (temperature, humidity, barometric pressure, clearness, temperature deviation from normal for the date, and wind speed) is so incomplete and ambiguous that little can be learned from his study.

Persinger (1975) had 10 students rate their mood four times per day (within one hour of awakening in the morning, before lunch, before dinner, and before sleep) from 9 January to 8 April (90 days). For each day an average mood score was calculated. He selected the following weather variables: the day's mean barometric pressure, greatest change of barometric pressure within 24 hours, greatest change in barometric pressure for any period of two hours, daily mean wind speed, number of sunshine hours, mean daily temperature, range of daily temperature, mean relative humidity, range of daily relative humidity, and a measure of daily global geomagnetic activity.

There were more significant individual time series correlations than expected by chance. Again, the report does not give a clear idea of the meaning of the individual differences which were found in the data. Over the three periods of 30 days each, the correlations of a person's mood scores with weather variables were rather unstable. The greatest percentages of significant ($p<.05$) correlations (about 20%) were found for mood at day n related to weather at days n-1 and n-2. Generally, mood scores were positively correlated with the number of sunshine hours and humidity range but negatively related with mean humidity, all weather variables taken into consideration with a time lag of one or two days.

Clear experimental evidence of differential effects of negative ions on aggressive behaviour depending on personality is provided by Baron, Russel & Arms (1985). Unexpectedly, Type A persons (classified according to Jenkins Activity Survey and generally described as being irritable and aggressive) were more aggressive with increasing concentration of negative ions, whereas Type B subjects were not affected. The authors assume that negative ions increase the activation level and therefore intensify whatever responses are prevalent.

Using Lacey's (1956) autonomic liability score (ALS), Charry & Hawkinshire (1981) were able to predict differential effects of positive ions on mood, skin conductance, and simple reaction time.

Sanders & Brizzolara (1982) did not find significant one- and two-day lag correlations between weather variables (relative humidity, temperature, and barometric pressure) and mood measures (mood adjective checklist; Nowlis, 1965). However, a canonical correlation between weather and mood variables was significant. In particular, over the observed ranges of temperature and barometric pressure, relative humidity was negatively related to the weighted linear combination of three mood variables (vigor, social affection, and elation). The authors do not refer to individual differences.

Although Goldstein (1972) and Persinger (1975) provide some evidence of individual differences in the effects of weather variables on mood, they do not tell us, at least not in a clear way, which personality dimensions are responsible for those differences. It is the purpose of our pilot study to explore the intraindividual covariation of meteorological and air pollution indicators with subjective well-being over four periods of ten days each in a more systematic way and to relate interindividual differences in sensitivity to weather changes to basic personality measures.

Originally, the data were collected for studying the impact of unemployment on subjective well-being (Kirchler, 1985). Later, the meterological measures were retrieved from the weather station and added to the data pool (Früehwirth, 1985).

Since our preliminary literature search did not provide any clear evidence of which personality dimensions can be expected to moderate the influence of weather parameters on mood, we refrained from specific predictions, but expected that the basic dimensions emotional stability and introversion/extroversion would be particularly relevant in a biometeorological context. These two dimensions are supposed to be rooted in the functioning of specific neurophysiological systems (Eysenck, 1967, 1985; Gray, 1981) which might be directly affected by specific weather conditions, ie with only minor cognitive mediation and awareness.

Method

Overview Using the time sampling diary of Brandstätter (1977, 1983), 14 men and 12 women, residents of the city of Linz, Austria, unemployed, aged between 19 and 39 years, had taken notes of their subjective experience over four periods of 10 days each between end of March 1983 and end of September 1983. For these same time periods meteorological data were retrieved from the files of the weather station. For each subject a multiple regression of mood on the weather variables was calculated. The standardized partial regression coefficients were conceived of a subject's measure of his/her sensitivity to weather changes and used as dependent variable in a 2 by 2 ANOVA with emotional stability (low-high) and intraversion/extroversion (low-high) as factors.

Time Schedule The first, second and third period of observation were in the first, second, and third month of unemployment; the fourth period took place 6 months after job loss. Between period 1 and 2 as well as between period 2 and 3, there was an intermission of 20 days each when no notes were taken. Depending on the subject's start with the diary records, period 4 which uniformly was located in September, was separated from period 3 by at least two, at most three months with the exception of one subject who started late (at the beginning of June) and had therefore only one month between the third and fourth period. Therefore, the bulk of data was collected during April, May, June and September 1983.

Time sampling diary The subjects answered three or four times a day at randomly selected points of time (see Footnote 1) the following questions in their diary: (1) "Is my mood at the moment clearly negative, rather negative, indifferent, rather positive, clearly positive?" (2) "Which adjectives describe my present mood best?" (3) "Why do I feel as I have indicated?" (4) "Where am I?" (5) "What am I doing?" (6) "Who else is present?" (7) "How free do I feel in the choice of my present activity?"

1 For each of the six segments of four hours (0.01 - 4.00; 4.01 - 8.00; 8.01 - 12.00; 12.01 - 16.00; 16.01-20.00; 20.01 - 24.00) randomly one point of time (0, 15, 30, 45 minutes after the hour) was selected for observation. Each subject had his/her own independent random sequence of recording time.

After each ten day recording trial, the participants were instructed to code the diary entries themselves in order to guarantee complete anonymity and a classification of situations according to the subject's own understanding. The coding scheme was discussed and designed together with the subjects. The following categories were used: (1) Hour and date of note taking; (2) mood-state (5-point scale: -2, -1, 0, +1, +2); (3) time perspective (they had to indicate whether their current mood derived from past, present, or future events); (4) attribution of mood (here they had to indicate who or what caused their current mood-state, eg friends, spouse, leisure activity, economic situation); (5) motives involved (the subjects had to choose up to three different motives from a list of 19 motives, eg need for affiliation, need for achievement); (6) room or locality (eg own flat, shop); (7) activity performed at the time (eg doing nothing, watching TV); (8) other persons present; (9) perceived freedom (5-point scale); and (10) freely chosen adjectives describing the mood-state (eg happy, angry, sad).

The subjects were paid for their participation in the study AS 2000 (equivalent to 100 US dollars at that time).

Meteorological data The weather data from the files of the centre for meteorology and geodynamics in Vienna (see Footnote 2) included:

(1) Temperature in centigrade, measured with the dry thermometer.
(2) Steam pressure (mm mercury column)
(3) Visibility (in kilometres)
(4) Cloudiness (a scale from 0 to 10)
(5) Wind speed (scale of Beaufort, ranging from 0 to 12)
(6) Precipitation (0 = no, 1 = yes)
(7) Barometric pressure (mm mercury column)

All of these measures had been taken three times a day, 7.00 am, 2.00 pm, and 7.00 pm.

The air pollution data were provided by the Public Health Department of the city of Linz (see Footnote 2). Since Linz is an industrial city, dust and SO_2 concentration (milligramme per m^3 air) are the most important pollution indicators. Each of the three measuring centres located in different areas of Linz registered the pollution data twice an hour. The averages across centres for three periods of eight hours each (0.01-8.00; 8.01-16.00; 16.01-24.00) were used as air pollution measures in this study.

Personality Test The factor scores (second order) of the German version of Cattell's 16-PF test were used to measure the subjects' emotional stability (QII) and introversion/extroversion (QV) (Schneewind, Schrösder & Cattell, 1983).

Statistical Procedure A subject's series of daily averaged mood scores (-2 clearly negative to +2 clearly positive) over 40 days (see Footnote 3) provides the dependent variable. The daily averages of the seven meteorological variables and the air pollution indicator make up the independent variables. The multiple regression of mood at time t on mood at time t-1, air pollution and weather variables (W_i) at time t, all variables measured in z-scores, is calculated for each individual by a least square estimation of an auto-regressive model which cleans the residuals from the first order auto-regressive effects (Judge et al, 1985; White & Horsman, 1983). The model can be written in the following way:

$$z(mood_t) = \beta_0(mood_{t-1}) + \beta_1 W_{1t} + \beta_2 W_{2t} + ... + \beta_n W_{nt} + error$$

The standardized partial regression coefficient of a weather variable indicates how much (in standard z-scores) mood changes when the weather variable changes by one unit (z-scores) while the other variables are held constant. A positive sign indicates better mood with higher weather scores.

These standardized partial regression coefficients (indicating the subject's sensitivity to changes in weather and air pollution) were used as dependent variables in a 2 x 2 ANOVA with emotional stability (low - high) and extroversion (low - high) as fixed factors.

Using regression coefficients as dependent measures in an ANOVA design may not be common practice, but we can see no convincing argument against it. An alternative procedure would be to calculate an average mood score for each person in each class of k weather conditions and to run a k x 2 x 2 ANOVA (weather conditions by introversion/extroversion by low vs. high emotional stability). However, this would not allow for testing partial effects of the weather variables, if each weather variable, reduced to two or three ordered categories, were separately combined with the personality dimensions (see Footnote 4).

Results

Correlations between weather and air pollution variables The correlations of Table 1 are based on the daily averages of air pollution and weather variables, observed in 1983 at Linz (Austria), for the following time periods: March 26 to April 4, April 16 to May 4, May 15 to June 3, June 9 to June 22, July 9 to July 18, August 8 to August 17, September 9 to September 18, September 29 to October 8 (see Footnote 5).

As Table 1 shows, the air pollution indicators of SO_2 and dust are highly correlated with each other ($r= .59$; $p<.01$), and moderately correlated with temperature, cloudiness and precipitation. Other correlations are found between steam pressure and temperature ($r= .57$; $p<.01$) and between precipitation and cloudiness ($r= .47$; $p<.01$).

Individual differences in sensitivity to air pollution and weather changes Table 2 displays the standardized partial regression coefficients of mood at the time t on mood at time t-1, air pollution, and seven weather variables at time t for each of the 26 subjects. The variable "air pollution" is the average of the standardized variables "SO_2" and "dust". Including both highly correlated variables in the regression analysis would have caused a problem of colinearity. All variables come up with more significant regression coefficients than expected by chance. Therefore, it seems justified to explore the relationship between a subject's personality structure and his/her sensitivity to air pollution and weather changes.

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2 We are indebted to Dr Neuwirth (Vienna) and Dr Glötzl (Linz) for their kind assistance in collecting the weather and air pollution data.

3 For subjects 5, 13, and 21 the fourth period (September) is missing. We have linked together the different periods of observation as if no time gap were between the periods.

4 We thank Franz Auinger, Gernot Filipp and Hannes Lehner for their assistance in statistical analysis and manuscript editing.

5 The selected time segments correspond to the non-overlapping time samples of subjects 5, 12, and 24 which were combined in order to arrive at an approximately equal distribution of observations over the different months. Missing data reduced the number of days to N=84.

Table 1
Correlations of weather and air pollution variables

		SO2	DUST	TEMPER	STEAMP	VISIBI	CLOUDI	WINDSP	PRECIP	BAROME	MEAN	STD DEV
(1)	SO2	-	.59	.24	-.21	.08	-.42	.04	-.34	-.36	.03	.02
(2)	DUST		-	.34	.13	-.10	-.38	-.08	-.30	-.13	.10	.05
(3)	TEMPERATURE			-	.57	.19	-.37	-.06	-.35	.10	17.11	5.36
(4)	STEAM PRESSURE				-	-.27	.12	-.14	.18	.26	9.14	2.24
(5)	VISIBILITY					-	-.14	.12	-.20	.02	7.44	2.92
(6)	CLOUDINESS						-	.16	.47	.08	5.81	3.67
(7)	WINDSPEED							-	.12	-.18	1.79	.94
(8)	PRECIPITATION								-	.11	.24	.33
(9)	BAROMETRIC PRESSURE									-	734.24	4.85

Note. Scales of the weather variables: (1) and (2) mg per m^3 air; (3) centigrade; (4) mm mercury column; (5) km; (6) 0 - 10 in tenths of the sky covered by clouds; (7) Beaufort scale from 0 (calm) to 12 (hurricane); (8) 1 = yes, 0 = no; (9) mm mercury column N = 84.

Table 2
Individual Differences in Sensitivity to Weather and Air Pollution Changes (standard partial regression coefficients), based on daily averages

SUBJE	MOOD	POLLUT	TEMPER	STEAMP	VISIBI	CLOUDI	WINDSP	PRECIP	BAROME	MULTIPLE R	EXTROV	EM.STAB.
1	0.00	-0.42	0.01	0.21	0.03	0.38	-0.25	-0.70	-0.33	0.33	+1	-1
2	0.54	0.16	0.02	0.15	0.48	-0.07	0.26	0.39	-0.22	0.38	+1	+1
3	-0.02	-0.18	0.62	-0.40	-0.56	0.23	-0.09	-0.32	0.08	0.34	+1	-1
4	-0.14	-0.11	0.60	-0.24	-0.28	0.56	0.17	-0.08	0.30	0.49	-1	+1
5	0.29	-0.19	-0.27	0.65	-0.27	-0.24	0.49	-0.38	0.05	0.63	-1	+1
6	0.24	0.00	0.08	0.16	0.23	0.21	0.26	0.01	0.19	0.28	-1	-1
7	-0.59	0.20	0.10	-0.32	0.34	0.06	-0.51	0.25	0.07	0.53	+1	-1
8	-0.14	0.21	-0.25	-0.37	-0.04	0.14	0.07	0.45	-0.49	0.48	-1	-1
9	0.01	0.42	-0.49	-0.03	0.31	0.04	0.08	-0.10	-0.07	0.31	-1	-1
10	-0.50	0.19	-0.47	0.14	0.18	-0.19	0.20	-0.20	-0.15	0.30	-1	-1
11	-0.33	-0.17	0.25	-0.09	0.20	-0.01	-0.05	0.35	-0.23	0.38	+1	-1
12	-0.07	0.41	-0.31	0.33	0.29	0.07	0.01	0.28	0.12	0.20	+1	+1
13	0.25	-0.45	0.15	-0.83	0.43	-0.09	-0.20	0.49	-0.96	0.67	+1	-1
14	0.04	1.07	-0.56	-0.11	0.05	0.75	-0.31	-0.01	-0.20	0.53	+1	+1
15	0.24	-0.15	0.15	0.26	-0.25	0.04	-0.03	-0.35	-0.11	0.21	-1	-1
16	0.16	0.29	-0.56	0.61	0.26	-0.52	-0.07	0.17	0.24	0.53	+1	+1
19	0.29	-0.43	0.28	-0.13	0.14	0.21	0.23	0.31	-0.35	0.40	-1	+1
20	0.30	0.28	-0.78	0.33	0.23	-0.54	-0.11	-0.03	-0.05	0.24	+1	+1
21	-0.37	-0.09	-0.27	0.40	0.16	-0.05	0.38	0.09	0.30	0.38	+1	+1
22	-0.04	-0.18	-0.24	0.35	0.31	-0.17	0.05	-0.12	0.28	0.23	-1	+1
23	-0.50	0.18	-0.64	0.30	0.22	-0.22	-0.38	-0.20	-0.04	0.68	-1	-1
24	-0.06	0.05	0.55	-0.06	0.57	0.64	0.59	0.06	-0.38	0.56	-1	-1
25	-0.37	0.03	-0.68	0.42	0.02	-0.33	-0.20	-0.32	0.15	0.21	-1	-1
26	0.12	-0.03	0.13	0.41	-0.06	-0.25	0.08	-0.36	0.19	0.43	+1	+1
27	-0.51	0.49	-0.82	0.16	-0.43	-0.76	0.10	0.28	0.40	0.36	+1	+1
28	-0.18	-0.25	0.17	-0.30	-0.14	-0.26	0.11	-0.53	0.21	0.50	-1	+1

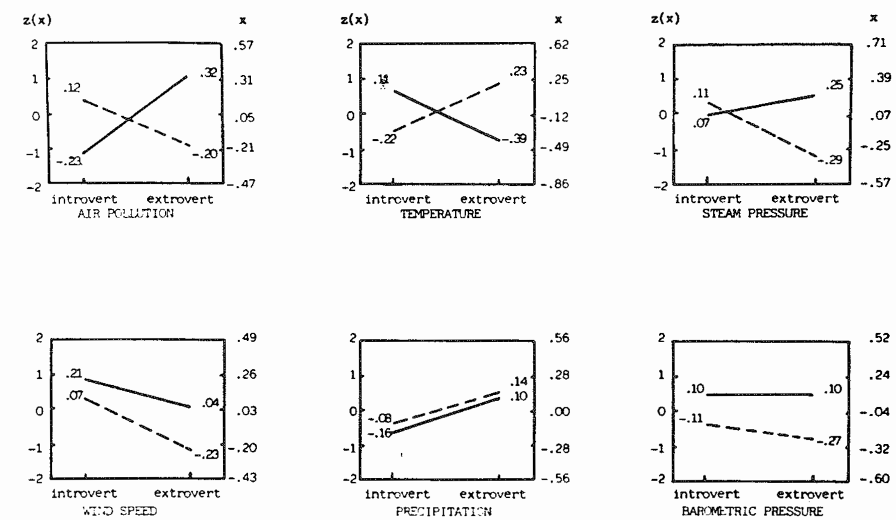
Note. Underlined coefficients are significant at $p<.10$.
Personality variables: Introversion/Extroversion (-1,+1)
Emotional stability (low=-1,high=+1)

Sensitivity to air pollution and weather variation related to personality structure Analyses of variance with emotional stability and introversion/extroversion as independent variables and each (one by one) of the air pollution and weather regression coefficients of Table 2 as dependent variables give the results presented in Figure 1.

We find significant interaction effects for air pollution $F(1,22) = 17.78$; $p<.000$), temperature ($F(1,22) = 10.24$; $p<.004$), and steam pressure ($F(1,22) = 4.97$; $p<.036$). In addition, there are significant main effects of extroversion ($F(1,22) = 6.30$; $p<.020$) and emotional stability ($F(1,22) = 4.72$; $p<.041$) for wind speed, of extroversion for precipitation ($F(1,22) = 4.60$; $p<.043$), and of emotional stability for barometric pressure ($F(1,22) = 6.50$; $p<.018$) (see Footnote 6).

Figure 1

The influence on mood at time t of air pollution, temperature, steam pressure, wind speed, precipitation, and barometric pressure at time t dependent on patterns of emotional stability (--low, ¯ high) and extroversion.



Note The influence measure (sensitivity) X is a standardized partial regression coefficient. A positive value means that a subject's mood is improving with higher values of the weather variable. The scale on the left side is a linear transformation $z = (X - X)/s(X)$ where $s(X)$ is the pooled standard error of the influence measure allowing an estimate of effect sizes (Cohen, 1977, p20).

Regression of mood on difference scores of weather and air pollution variables People often complain about sudden changes in weather conditions. Do our data support the idea that mood is affected not so much by the weather of the present day but by changes of

6 The pattern of results with daily averages is very similar to that based on three observations per day which has been presented in an earlier version of the paper at the Lisbon conference, although the individual difference patterns of effects for air pollution, steam pressure, and precipitation missed the 5%-level of significance by a small margin and were therefore not included in the preliminary report.

the weather from the past day? We tried to answer this question by testing the following model:

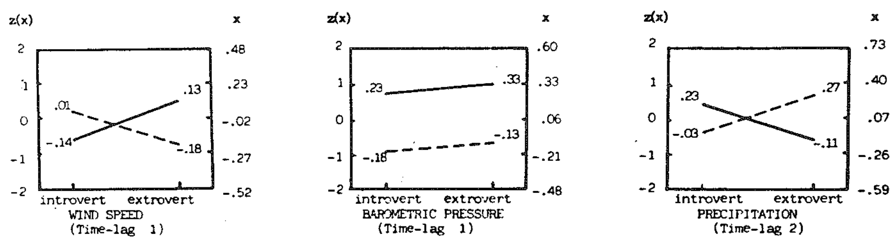
$$mood_t = \beta_0 mood_{t-1} + \beta_1(W_{1,t}-W_{1,t-1}) + \beta_2(W_{2,t}-W_{2,t-1}) + \ldots \beta_n(W_{n,t}-W_{n,t-1}) + error$$

In the sensitivity to daily weather changes, there were neither general effects, nor individual differences related to patterns of emotional stability and introversion/extroversion.

Regression of mood (time t) on weather and air pollution variables at time t-1 and time t-2 As Figure 2 shows, only wind speed (interaction of extroversion and emotional stability: $F(1,20) = 4.59$; $p<.05$) and barometric pressure (main effect of emotional stability: $F(1,20) = 14.47$; $p<.01$) at time t-1 have differential effects on mood at time t. With time lag 2, there is an interaction effect for precipitation ($F(1,18) = 4.75$; $p<.05$).

Figure 2

The influence on mood at time t of wind speed and barometric pressure at time t-1, and precipitation at time t-2, dependent on patterns of emotional stability (--- low, ___ high) and introversion/extroversion.



Note *The influence measure (sensitivity) X is a standardized partial regression coefficient. A positive value means that a subject's mood is improving with higher values of the weather variable. The scale on the left side is a linear transformation z = (X - X)/s(X) where s(X) is the pooled standard error of the influence measure allowing an estimate of effect sizes (Cohen, 1977 p 20)*

Discussion

It has come as a surprise that weather and air pollution seem to have almost no general effects on subjective well-being (see Footnote 7). As yet we have no convincing explanation for this unexpected result. It is still possible that there exist some non-linear weather effects, eg very low and very high steam pressure could be equally uncomfortable. In addition, patterns of weather variables may allow better general predictions than simple linear combinations. Faust (1977, p.51f) describes several systems of classifying weather configurations which proved useful in a biometerological context and which might be applicable also to studying the weather effects on mood.

However, it may well be that within a normal range of weather variation no general effects can be found at all, that the emotional sensitivity to weather variation depends largely on the personality structure as our data suggest. The adverse effects of certain weather conditions as shown by epidemological studies on behaviour disorders may be true

7 Only high visibility is generally more often connected with positive mood than with negative mood (18 out of 26; cf Table 2).

for specific personality structures only, whereas other types of persons may profit from these same conditions. To assume that a weather which is linked to high rate of violence, suicide or psychiatric admission should be more or less harmful to everybody could simply be wrong.

Before we encourage the reader, particularly those who know more about biometeorology than we do, to speculate about the mechanisms which could explain the patterns of our results, we have to think about possible sources of contamination of the data. Can we be sure that the weather influences the mood states directly via physiological mechanisms, or is it that mood covaries with activities which in turn depend on the weather? Could it be that individual differences in covariation between duration of unemployment and mood on the one hand, time of the year and weather on the other hand, caused a spurious correlation between weather and mood?

We tried to answer these questions by running regression analyses including season (ordinal number of week) and type of activities as independent variables together with the weather and air pollution indicators, thus partialing out their effects. The results were virtually unchanged. Obviously, we can be quite confident that the weather directly influences peoples' mood in ways which depend on patterns of emotional stability and extroversion.

We would have liked to see if the effects of the weather on a person's mood are the same in each of the four periods of observation which were distributed over six months, or if there are seasonal patterns of effects. Unfortunately, the time series were too short for such a stability check of a person's sensitivity to weather changes.

In interpreting the results of Figures 1 and 2 we have to keep in mind that we used the standardized partial regression coefficients as indicators of a person's mood changes dependent on the respective weather variable while the other weather variables held constant. Thus, if the mood of emotionally unstable extroverts is improving with increasing termperature (within the range of moderate temperatures of the months April, May, June, and September when most of the data was collected) while holding constant steam pressure (and the other variables), this is equivalent to saying that unstable introverts feel better with decreasing relative humidity.

None of the results presented in Figures 1 and 2 are obvious and self-explanatory. Why unstable extroverts feel best when the weather is warm, dry, and calm (high temperature, low steam pressure, and low wind speed), whereas unstable introverts feel better in cool weather, without being affected by steam pressure and wind speed, is not immediately clear.

That stable extroverts suffer in hot and dry weather reminds one of Curry's (1946) W-type which is characterized by a similar personality structure and sensitivity to high temperature, whereas the K-type's personality structure and weather sensitivity resemble that of the (stable?) introvert. Although this may be seen as a kind of correspondence in the description of individual differences in reactions to temperature variation, it is far from an explanation.

According to our data, high wind speed and high barometric pressure are better for emotionally stable than for emotionally excitable subjects. We also cannot tell why this should be so.

Persinger (1975) and Sanders & Brizzolara (1982) found high relative humidity connected with bad mood, and Cunningham (1979) reported less helping when relative humidity was high. In contrast, our data shows a negative impact of steam pressure, ie absolute humidity, on mood only for extroverts. It may well be that the forementioned authors would have detected the same individual differences if they had looked for the effects of extroversion and emotional stability.

Since the ionization of the air varies with air pollution and weather changes (cf Faust, 1977, p.172f), experiments like those performed by Baron, Russel & Arms (1985) and Charry & Hawkinshire (1981) have some relevance in the context of our problem. One could imagine that the weather effects on mood are in part due to changing concentrations of negative and positive ions in the air. Unfortunately, as we have no data on the ionization of the air in our study, this path has to be explored with new data.

Of course, any correlation between meteorological variables and mood is equivocal in terms of causation. Although we can neglect causal effects of mood on air pollution and weather (people are happier during holidays, they drive a lot and pollute the air), we must be aware that some of the apparent weather effects might be mediated by socially shared obligations, preferences, or opportunities to specific activities dependent on short and long term weather conditions (a rainy weekend spoiling the joys of outdoor recreation; activity patterns varying with the season). Any time related variable like adaptation or sensitization to unemployment can be confounded with the effects of seasonal weather changes. Even personality differences in the covariation of mood and weather could be caused not so much by a direct physiological influence of the meteorological variables, but by individual differences in activity patterns and their personal meaning dependent on the weather. Thus, during hot summer days foresters might feel quite comfortable working in the woods, whereas waiters in restaurants without air conditioning might feel tormented; what if foresters were more introverted and waiters more extroverted? Or if economic well-being in a certain culture were related to personality differences, allowing some people to protect themselves better than others against the discomfort of cold, wet, and windy weather or against the summer's heat, we would again find apparent individual differences in the covariation of weather and mood which are social and not primarily physiological.

Notwithstanding all these imminent fallacies of which we were consistently aware, we are inclined to believe that at least some of our results need biometeorological rather than psychological explanations.

Finding out about the physiological mechanisms underlying differential effects of weather on mood remains a task for future interdisciplinary cooperation in developing and testing appropriate theories. It seems to us that Hellpach's (1965; 1977) imaginative work is still a good starting-point for such an endeavour.

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