The effect of weather on mood, productivity, and frequency of emotional crisis in a temperate continental climate

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Abstract. A group of 62 mostly university student subjects kept structured diaries of their feelings and their productivity for six weeks in Illinois in early autumn. During the same period, daily frequency of telephone calls to a crisis intervention service in the same community was monitored, and complete daily weather data for the vicinity were provided by a local meteorological research facility. Major findings are as follows. The weather appears to influence mood and productivity, but only to a small extent compared with the aggregate of all other controlling factors. Males show a relatively stronger effect than females. Psychologically troubled people generally appear to be more affected by weather than university students. The students and the crisis intervention service clients with "mild" problems tend to be stressed more when the weather is unstable, cloudy, warm and humid, and least stressed during sunny, dry, cool weather with rising barometric pressure. The crisis service clients with "severe" problems react oppositely to these two weather types. The meaning of these and other results and the strengths and weaknesses of this study's design are discussed.

Key words: Psychology – Weather – Mood – Emotional crisis frequency – Productivity – Temperate climate

Introduction

Many studies have been carried out to determine the nature and extent of the weather's effect on a wide variety of human behavior: illnesses, frequency of police calls, job accidents, birth and death rates, and psychological states such as suicidality or malaise. Weather has long been considered to influence not only peoples' conscious subjective feeling but their digestive, cardiovascular and respiratory systems as well. Although the actual causal relations have never been isolated, numerous studies have shown reasonably stable correlations between certain meteorological variables and human functioning and/or behavior.

Admission frequencies to a military neuropsychiatric clinic in western New York state were found to be highest during the winter, the exact peak time varying with clinical diagnosis (Chambers 1956). More surprising was the statistically significant relationship between earth geomagnetic field intensity and admission rates between 1957 and 1961 at seven central New York state psychiatric hospitals and Veteran Administration general medical and surgical hospitals (Friedman et al. 1963).

Occurrences of specific illnesses have been given the most attention in the weather-behavior literature. A state medical hospital in East Moline, Illinois was found to have lowest admissions rates in winter and highest in spring and summer. Sex differences were not demonstrated (Hauck and Armstrong 1959). After convincingly showing that gastric and duodenal ulcers are more frequent in winter in a London hospital, a follow-up study (Langman 1964) failed to detect a relation between these two ulcer forms and departures from normal of London's mean monthly temperatures. Similarly, a large sample of Chicago ulcer patients under 50 years of age showed increased problems during abrupt pressure changes such as those that occur in winter with the passage of midlatitude cyclones, but not during equally abrupt temperature changes (Berg et al. 1968). Hansen (1970) found that sudden barometric pressure changes (i.e., >2.5 mb hr^{-1}) were associated with onset of peripheral arterial embolism, whereas general pressure level or gradu-

al, steady changes had little effect. A later study demonstrated that perforated duodenal ulcers also behaved this way in relation to pressure (Hansen and Pedersen 1972). In both cases it was suggested that the sudden weather changes associated with a quickly changing barometer might be the crucial parameter rather than the pressure change per se.

As a counterbalance to the apparently strongly positive findings above, one study (Schlossberg 1974) detected no marked correlations between pressure or any meteorological variable and emergency visits or first time nonemergency visits to a large Detroit medical hospital during 1973. It was suggested that previous significant findings could have been caused by uncontrolled confounding variables such as differential medical judgement or available hospital space.

Muecher and Ungeheuer (1961) studied not only illness behavior but perceptual and occupational behaviors as well, and found that during periods of unsettled or inclement weather (i.e., low pressure, overcast skies, precipitation, change from above- to below-normal temperatures) there were more requests for medical attention, more job accidents, higher laboratory flicker fusion frequency (i.e., higher sensory threshold) and longer laboratory reaction time. A crime/accident study in Fort Worth, Texas (Will and Sells 1969) indicated that (i) the maximum police call rate was associated with high temperature and low pressure (except for domestic disturbances) and (ii) the highest accident rate occurred when there was precipitation.

Studies on the relation between weather and suicide attempts have been either inconclusive or negative; for example, in a study of 440 Houston suicide attempts and their corresponding weather, no significant relationships were found (Pokorny et al. 1963).

Several studies have addressed the behavioral effects of the dry, windy, unseasonably hot weather produced by adiabatic compression of air descending a mountain range. This weather may occur on the east side of the North American Rockies (called a chinook), west of the Sierra Nevada Range in California (called the Santa Anas), and, more severely, north of the Alps (called foehn weather). Moos (1964) found that accident rates were somewhat higher in Zurich, Switzerland just prior to and during foehn weather. Dordick (1958) suggested inconclusively that headaches, insomnia, irritability and debility are more likely during foehn or any weather characterized by high temperature and low pressure, and least likely during cold temperatures and high pressures that follow cold fronts. Foehn weather has even been impli-

cated as a cause of birth and death rate increases (Moos 1963).

Few studies have focused on the weather's influence on peoples' reported subjective feeling. In one such study at Texas Christian University (Findikyan and Sells 1964), students filled out a subjective feeling inventory. Although the female group showed a significant negative correlation between a humidity parameter and positive mood, the group as a whole showed no significant correlations. Somewhat similar studies using more sophisticated statistical methods (Persinger 1975, Sanders and Brizzolara 1982) suggested that "good" weather produces good feelings.

The present study is of this latter type in that it emphasizes subjects' states of mind rather than more directly measured behavior. Use of a somewhat larger sample size and time period makes this study's results less vulnerable to sampling error. Because the subjects participated completely voluntarily, very little measurement error can be attributed to indifference toward or annoyance with the task of filling out the daily diary. The study was designed to include a large number of meteorological variables, a relevant set of mood variables, and a subjectively-perceived productivity evaluation. In addition, the frequency of (and reasons for) calls received on a local emotional crisis hotline was monitored. The intent was to determine if (i) certain individuals show high degrees of influence by the weather, (ii) males or females, collectively, show sex-specific weather responsiveness, (iii) the entire subject pool shows any systematic mood or productivity changes in association with certain weather conditions, and (iv) people calling a crisis service for help with (a) ordinary problems (b) severe or abnormal problems tend to do so more under specific weather conditions.

The location of the study in central Illinois is appropriate for our purpose, being in a continental region at 40° north latitude that, especially in spring and fall, is subjected to frequent alternations between cold Canadian air masses and warm, moist subtropical air masses from the Gulf of Mexico.

Materials and methods

A variety of mostly undergraduate psychology classes at the University of Illinois at Urbana were used to recruit volunteer subjects. The resulting sample size and female to male ratio were 62 and 1.7, respectively. The mean age was 21 with a range from 17 to 43; 90% were between 18 and 24.

Each subject was provided with a six-week mood/productivity diary with instructions on the cover page defining the study period to be September 16 to October 27, 1974, to be returned at the end of the study period. The Champaign-Urbana Crisis Service (a function of the Champaign County Men-

Table 1. The diary scales and their defined low (*1*), middle (*5*), and high (*9*) ratings

Scale	Scale rating								
	1	2	3	4	5	6	7	8	9
Morale	Very gloomy				Average morale			In fantastic mood	
Nonirritability	Very irritable				Reasonable, but *could* get annoyed			Very good-natured	
Invulnerability	Very easily hurt				Average vulnerability			Very strong, secure	
Productivity	Wasted the day				Average accomplishments			Very productive day	
	1	2	3	4	5	6	7	8	9

tal Health Center) provided day-to-day client telephone call data. The Illinois State Water Survey's Atmospheric Science Section provided extensive daily weather data.

The Crisis Service, a free telephone call-in service staffed mostly with trained volunteers, handles a wide variety of emergencies and emotional crises. During the study period, frequencies of and reasons for Crisis Service calls were tabulated. The reasons for calling were sorted into two severity categories. The following were considered to be *ordinary* problems: family, financial, legal, loneliness, marital, relationships and school. The following were regarded as *severe* problems: alcoholism, anxiety, depression, drugs, sexual-homosexual, physical, psychosis and suicide. Prank calls and calls requesting information were not tabulated. The specific problem types in the above lists were decided by the trained personnel handling the calls. Neither the callers' sex nor the precise time of the call was obtained. The severity dichotomy is somewhat arbitrary, in that some marital problems may be severe, while some depressions are ordinary. In general, though, the problems of callers in the severe category tend to be of greater magnitude than those of callers in the ordinary category.

The daily mood inventories instructed the subject to indicate the lowest, the average, and the highest level that certain aspects of his/her mood assumed during the day. Three aspects of mood were included: morale, nonirritability and invulnerability. A behavioral functioning variable was included: productivity, which was to be evaluated subjectively by the subject; only the average value was requested. The meaning of the mood variables as perceived by the subjects is evident from the plus and minus poles of the four scales that were used (Table 1).

From the completed mood/productivity diaries, six parameters were obtained for each of the first three variables (morale, nonirritability, invulnerability): (1) minimum, which is directly indicated by the subject, (2) mean – directly indicated, (3) maximum – directly indicated, (4) range, which is the maximum minus the minimum, (5) skew, comprising a purely empirical total of a dimensioned and a dimension-free component which is computed from the minimum, mean and maximum in accordance with Eq. (1); the skew indicates the extent and direction of departure of the mean from the midpoint between the minimum and maximum, and (6) absolute value of skew, which depicts the magnitude of the skew regardless of the direction of the asymmetry of the mood distribution.

$$skew = (max\text{-}mean) - (mean\text{-}min) + \frac{(max\text{-}mean) - (mean\text{-}min)}{range}$$

(1)

If range = 0, skew is set to 0.

From the fourth variable (productivity), only the mean value was obtained. Hence, there were 19 parameters extracted from the diaries, 6(3) + 1. These were studied in three ways:

males alone ($N = 19$), females alone ($N = 33$), and the combined group ($N = 62$; 10 subjects failed to indicate their sex). The Crisis Service calls (constituting two additional variables) were included in the combined group data, resulting in 21 parameters for that condition.

The meteorological data that were secured from the Illinois State Water Survey in Champaign included several different aspects of the temperature, relative humidity, percent of possible sunshine, barometric pressure, precipitation and wind. Besides daily values, trends of different time scales were included. The names and definitions of the 36 weather variables are provided in the Appendix.

Two variables were considered that might contribute to the error variance in desired correlations: day of the study and day of week. The menstrual cycles of the female subjects were not monitored despite their possible relevance to day-to-day mood variability.

For the 42-day study period, correlations between all weather variables and all psychological variables were computed, following which factor analyses were carried out (see below).

Results

In considering the results, one should keep in mind that peoples' responses to particular types of weather are seasonally dependent. During January in Illinois many people enjoy brief respites from the usual below-freezing mean daily temperatures; in spring severe thunderstorms and tornado threats become important. At the time of the present study, a summer of above-average temperature had just finished, so that subjects might be expected to dislike very warm days. Although no uncomfortably hot days occurred during the study period, the temperature did rise somewhat above standard room temperature on several afternoons.

Correlations between moods of specific individuals and the weather

Because the correlation matrix between the 19 mood variables and 36 weather variables contains 684 correlation coefficients, purely random and normally distributed data are expected to yield about 34 coefficients significant at the 0.05 level,

7 of which are significant at the 0.01 level as well. For the number of days included (42), the highest coefficient is expected to be about 0.50 by chance alone ($p = 0.0015 = 1/684$).

In general the results for individuals corresponded to the chance expectations. Several subjects produced one or two 0.55+ correlations on varying combinations of variables, but for many the maximum correlation was below 0.45. The only overall departure from the chance distribution was that somewhat more than 50% of the subject matrices had fewer than 34 coefficients significant at the 0.05 level but had more than 7 significant at the 0.01 level. Many of the highest correlations were those involving skew and absolute value of skew of a given mood variable, although the simpler mood parameters were occasionally involved. The weather parameters involved were quite variable, but included forms of the temperature, pressure, rainfall and wind somewhat more frequently than forms of relative humidity and percent of possible sunshine. To ascertain whether actual underlying correlations exist between individuals' moods and the weather, factor analysis is helpful in that it greatly reduces the number of coefficients produced and thereby removes much of the uncertainty regarding significant coefficients indicating real versus accidental correlations. Because this technique was not applied at the individual subject level, the question of the weather's effect on individuals' moods remains open. However, it is clear that if there is an effect, it is certainly a minor one relative to the total of the sources of variability of an individual's mood.

Correlation between moods of sex-specific subject groups and the weather

For the statistical analysis of the three groups' data (male sample, female sample and total sample), each individual's daily scores on each of the diary variables were standardized with respect to his own mean and standard deviation over the 42-day period. This was necessary because many subjects did not fill out the diary every day (due to forgetting or being over 60 miles from Champaign-Urbana), and certain days would have biased values if, for example, the people who did not produce data happened to be the ones who generally tend to give high scale ratings. These individual subject standardized scores, which included those of different subjects from day to day, were averaged for each of the 42 experimental days. Each day, then, had its own mean of the within-subject standardized scores, which can be considered for our purposes

the raw scores of this study. The weather variables were also standardized.

For increased clarity, the multivariate statistical procedure applied to the three groups' data and the weather data will be described in the male sample results section rather than in general terms here.

Male sample results

The correlation matrix for the weather and the male sample showed about as many 0.05- and 0.01-significant occurrences as would be expected by chance. A summary of all coefficients of at least 0.05-significance is provided by the m and M entries in Fig. 1, where m denotes significance at the 0.05 level, M at the 0.01 level, and minus signs negative correlations.

Because of the high probability that many of the significant correlations are due to chance alone, a factor analysis was performed on both the weather variables and the psychological variables. To eliminate linear dependence (and near-linear dependence) among the original variables, several of them were removed prior to the factor analysis. For example, average temperature was removed because it can be determined with fairly good (not perfect) accuracy from the AM and PM temperatures. All minimum and maximum mood values were eliminated since the mean and range give an adequately complete description. The skew was eliminated (absolute value of skew was retained) because the initial correlations revealed that it might tend to overshadow more meaningful psychological variables in the factor analysis. (The skew and absolute value of skew were included in the study in hopes of their being active simultaneously across the three mood scales in analogy to the mean values tending to be mutually positively correlated. Since this was not the case, we need not care about the specific cross-scale pairings of these asymmetries no matter how highly systematic they may be.) The remaining 28 weather variables and 10 mood variables, 3(3)+1, were subjected to separate factor analyses. Factors with eigenvalues of at least one were retained (Guttman 1954), unless a slightly less-than-one eigenvalue appeared to cluster with the next higher eigenvalue, in which case it was retained. Results yielded 7 meteorological factors and 4 male mood factors. The time-dependent factor scores corresponding to the weather and mood factors were then intercorrelated. With only 28 correlation coefficients expected in the correlation matrix, the problem of accidental statistical significance is greatly reduced.

Table 2. Interpretation of the rotated factors

Rotated weather factors

1 Fair and cool, high pressure, windy
2 Morning drizzle after previous day rain, cold,
   clearing by afternoon, windy, partly cloudy
   and dryer, remaining cool
3 Rapidly rising pressure, very windy, clearing,
   warm but turning colder
4 Substantial evening rain
5 Early clearing, much dryer and sunnier
   than previous day
6 Substantial afternoon rain, ending by early evening
7 Rapid warming trend, falling pressure, windy

Rotated male mood factors

1 (Loadings multiplied by -1) high productivity,
   asymmetric morale and invulnerability distributions
2 Asymmetric nonirritability distribution,
   high morale range
3 High invulnerability and nonirritability ranges
4 High morale, high nonirritability,
   high invulnerability, asymmetric morale distribution

Rotated female mood factors

1 Asymmetric nonirritability distribution,
   symmetric invulnerability distribution,
   high nonirritability range
2 (Loadings multiplied by -1) productive,
   low invulnerability range
3 Asymmetric invulnerability distribution,
   high morale range
4 High morale, high nonirritability,
   high invulnerability

Rotated total sample and Crisis Service calls factors

1 High morale range, high productivity,
   high nonirritability range
2 High morale, high nonirritability,
   high invulnerability
3 High frequency of severe Crisis Service calls
4 High frequency of ordinary Crisis Service calls

Table 3. Rotated weather versus mood factor correlations having 0.05-significance or greater. *W4* denotes "weather factor 4", etc. Correlation coefficient is followed by two-tailed significance level

Male mood versus weather		
W5 vs. M1	-0.30	$p = 0.05$
W4 vs. M3	-0.38	$p = 0.02$
W6 vs. M4	-0.40	$p = 0.02$

Female mood versus weather		
(none)		

Total sample mood (and CS calls) versus weather		
W1 vs. M1	-0.35	$p = 0.02$
W3 vs. M2	0.32	$p = 0.04$
W7 vs. M4	0.45	$p = 0.005$

both the factor correlations and the correlations among the original variables.

The interpretations of the rotated weather factors and the rotated male mood factors are shown in Table 2. The list of significant rotated factor correlations is provided in Table 3.

The conclusions are based on five correlation matrices: the large original one (not shown) and the four factor correlation matrices of varying rotation status (three not shown). The correlation required for 0.05 significance is 0.307 and that for 0.01 significance is 0.403. The significance levels cited in the following conclusions are composites of the significance levels of the correlations found for the relevant components of the conclusion in question.

In general, the male factor correlations contain more significant coefficients than chance expectation. Results indicate that better moods (happier, less irritable and less vulnerable) occurred during rising pressure ($p = 0.02$). Warm temperatures were preferred to cold ($p < 0.05$) and windiness over windlessness ($p < 0.05$). Relatively negative moods occurred if there was substantial afternoon rain unless it was in the form of scattered showers preceded by a partly sunny, windy midday with rising pressure ($p < 0.05$). Moods remained at a more constant level within a day when there was rain during the second half of the day ($p < 0.05$). There is weak evidence that males tended to be more productive when it cleared and became sunny and dry after a wet period ($p = 0.08$). Several relationships involving mood asymmetry are present, but they are ignored since they are of little meaning with respect to the influence of the weather when they appear in a scale-specific manner.
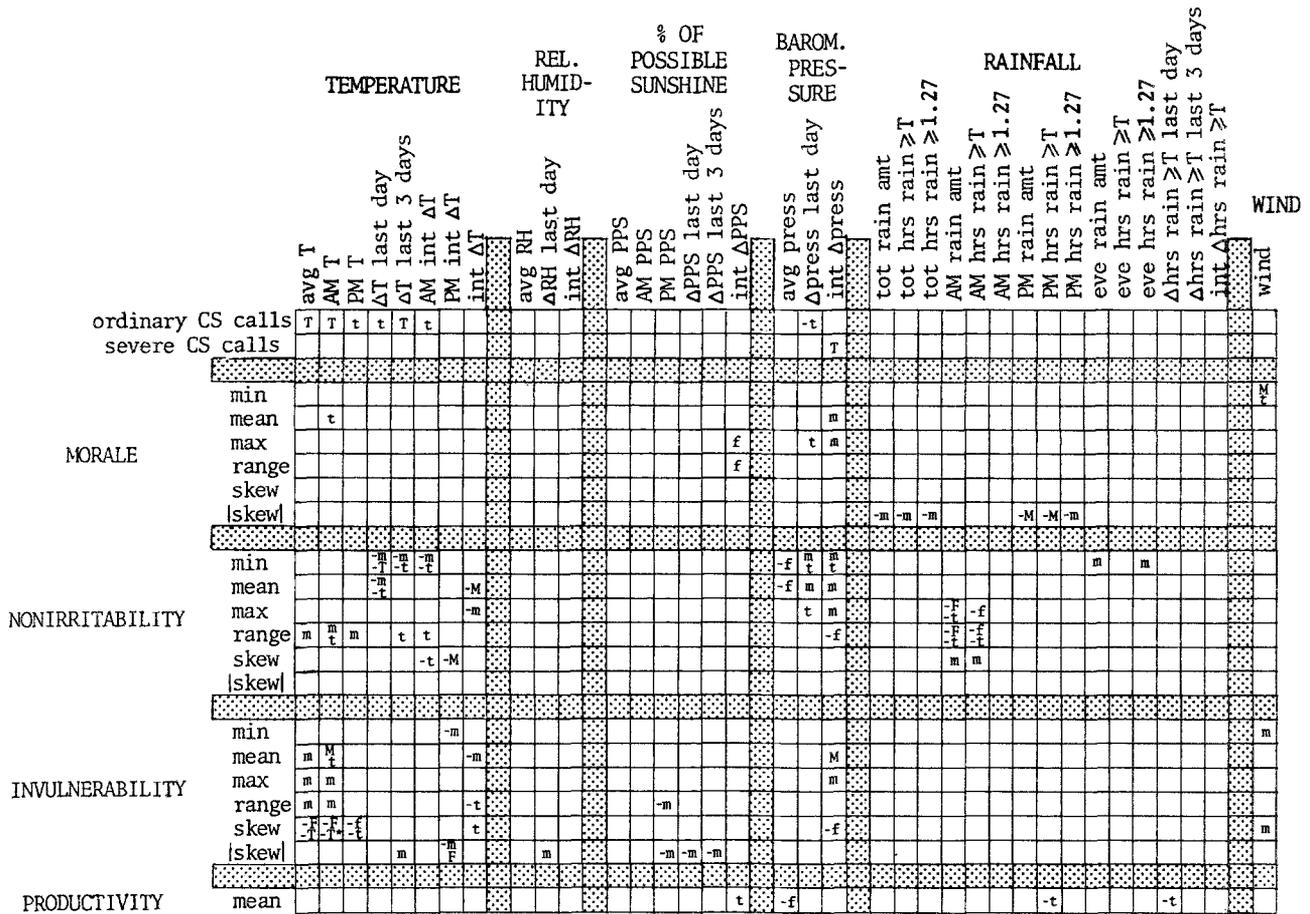
To further simplify the weather-mood relationships, the factor loadings were orthogonally rotated using varimax (Kaiser 1958, 1959), such that fewer but stronger non-zero loadings appeared. An example of this simpler factor structure will be provided below in the discussion of the moods of the total (male plus female) sample. Additional correlations were then obtained between unrotated weather factors and rotated male mood factors, between rotated weather factors and unrotated male mood factors, and between both rotated factor sets. Although some repetition of findings may occur, this technique is likely to capture the important basic relationships and very unlikely to miss any "hidden" relationships.

A good idea of what the factors represent can often be acquired from the factor loadings. Conclusions can then be formulated on the basis of

Fig. 1. Statistically significant relationships between weather and human behavior or moods, for males (m or M), females (f or F), and total sample (t or T). *Lower case* entries denote 0.05 significance, *upper case* 0.01 significance, and *asterisk* 0.001 significance; *minus signs* indicate negative correlations

Female sample results

The female mood versus weather 0.05- and 0.01-significant coefficients are shown in Fig. 1 by the f and F symbols, respectively. The correlation matrix as a whole contained fewer significant correlations at both the 0.05 and the 0.01 levels than would be expected by chance, indicating that the female group's states of mind may not have been affected noticeably by meteorological situations.

The factor analysis for female moods, to be correlated with that of the weather variables (outlined above in the male results section) yielded 4 factors of eigenvalue one or higher. The meanings of the rotated female mood factors are given in Table 2, while the lack of any significant correlations of these factors with the rotated weather factors is shown in Table 3.

The female factor correlations with the weather factors contain no more significant coefficients than chance expectation. Those that are significant involve the weaker factors on the hierarchies and

do not converge well conceptually with the few significant correlations of the original variables. No statements with evident statistical significance can be made as could be for the male sample. There is only a weak ($p = 0.15$) suggestion that the women were more productive when the pressure was low, more irritable when there was morning rain, and more elated when there was more afternoon than morning sunshine.

Correlations between the total sample moods (and Crisis Service calls) and the weather

The total (male and female combined) sample data included the two categories (ordinary problem, severe problem) of Crisis Service call frequencies. The 0.05- and 0.01-significant coefficients are shown in Fig. 1 by the t and T symbols, respectively. It should be noted that because ten subjects who failed to indicate their sex are in the total sample but in neither single-sexed sample, the total

sample statistics are not determined by those of the two subsamples.

The correlation matrix contains more significant coefficients at both 0.05 and 0.01 levels than would be expected by chance. Correlations with Crisis Service calls are especially strong and numerous. The factor analysis for total sample moods, to be used in relation to that of the weather variables (outlined above in the male results section), yielded 4 factors whose eigenvalues were at least one; the loadings of the original variables on these factors following the varimax rotation are shown in Table 4. The rotated factor interpretations that become evident are given in Table 2, and the list of significant factor correlations created by rotated total sample factors and rotated weather factors appears in Table 3. The total sample factor correlations with weather factors contain much stronger and more numerous significant coefficients than chance expectation. Factors upon which Crisis Service calls are heavily loaded contribute greatly to this pattern.

The group tended to find rapid within-day warming trends to be depressing, irritating and conducive to emotional vulnerability ($p < 0.01$). The irritating facet is the most outstanding. Falling pressure in combination with a warming trend added further to the aversiveness. Rising pressure was associated with good moods ($p < 0.01$) as was clearing, cooler weather ($p < 0.01$). High productivity was more likely to occur during days with clearing, windy afternoons preceded by a rainy period, and least likely on days that start off sunny but become cloudy or rainy late ($p < 0.05$). Moods tended to vary more within a day when it was sunny, windy and cold with high pressure; they were most constant throughout the day on partly cloudy, warming windy days with morning rain and high pressure ($p < 0.05$).

The Crisis Service calls frequency covaried systematically with the weather. Severe calls were least frequent with warming, humid, unstable conditions with dropping pressure, and more frequent when it was sunny and cool with rising pressure ($p < 0.01$). Calls for ordinary problems occurred most frequently when the severe calls were least frequent: in very warm, increasingly cloudy, unstable conditions with falling pressure ($p < 0.01$). Cool, clearing weather was associated with fewer ordinary calls. Calls of both types occurred most often when it was partly to mostly cloudy, warm and windy with rising pressure ($p = 0.02$), though the frequency of either type of call by itself was further maximized with the above-mentioned conditions.

Table 4. Rotated total sample (and Crisis Service calls) factor loadings

Original mood variable	Factor 1	Factor 2	Factor 3	Factor 4
"Mild" Crisis Service calls	0.03	−0.06	−0.05	0.97
"Severe" Crisis Service calls	−0.03	0.02	0.97	−0.02
Mean morale	−0.19	0.70	−0.11	0.13
Range morale	0.68	−0.11	0.01	−0.09
|Skew| morale	0.04	0.06	−0.09	0.02
Mean nonirritability	0.11	0.44	−0.02	−0.08
Range nonirritability	0.33	0.09	−0.14	0.07
|Skew| nonirritability	0.32	0.17	−0.09	−0.11
Mean invulnerability	0.14	0.48	0.03	−0.08
Range invulnerability	0.10	0.06	0.07	0.02
|Skew| invulnerability	0.22	−0.02	−0.06	0.03
Mean productivity	0.46	0.17	0.02	0.02

Multiple correlations were computed, using the 7 weather factors as predictors and each individual psychological factor as the predictand. Although significant multiple R's did appear, they were less impressive than the zero-order correlations among factors. This tendency held for the male and female groups as well as for the total sample.

Discussion

The factor analyses were most helpful not only in reducing the size of the original correlation matrices, but also in identifying the dominant, mutually independent modes of weather variation. These composites of very specific features are more meaningful than any of those features in isolation, and are what Findikyan and Sells (1964) stated were missing in their mood-weather study.

It is interesting that correlations between rotated factor sets did not in general surpass those of unrotated sets. Perhaps the simplest factor representation is not necessarily that which enters into the strongest relationships.

The results of this study are somewhat tenuous owing to the moderately short (42-day) time duration coupled with the fact that the weather was less variable than normal during those days (both in temperature and precipitation), reducing the signal-to-noise ratio.

Uncontrolled factors are an overwhelming problem in a study such as this. Day of week, day of study and female menstrual cycle phase confound the data. The former two variables were not partialled out in this study because they are only strongly linearly related to specific subsets of the mood variables at one time when coded in a given way. For example, day of week was found to corre-

late over 0.60 with total sample mean morale when the day of week was coded exactly according to the mean morale averages of each day of the week. (Tuesday produced the lowest average morale; Friday and Saturday nearly equally produced the highest.) But correlations with some of the other mood variables are close to zero when the coding is calibrated by mean morale. A scale-by-scale partialling out process was not attempted. Day of the study also proved to be very differentially related to the mood variables.

A complete study of this kind would have to last a full calendar year and be repeated in several major types of climate; otherwise, results are very circumscribed.

Some of the significant results obtained in this study are explainable. The negative reaction of the total sample to rapid warming trends is expected in early autumn in the midwestern United States. In the early spring the relationship would probably reverse itself, because people would have been exposed repeatedly to unpleasantly low rather than high outdoor temperatures in the preceding several months.

Past studies, upon discovering a relation between pressure and mood/behavior, have tended to attribute the effect to the weather associated with the pressure levels. This study tends to support the relation between pressure per se and moods. In most cases pressure alone has had an apparent effect on mood regardless of temperature, cloud cover or precipitation. Pressure change, even more than pressure level, appears to be important. The explanation for the preference for rising pressure (except for the severe Crisis Service callers) is not clear.

Increased productivity during sunny afternoons following rainy mornings or previous days is difficult to explain. Possibly the rain could have served as a brief diversion from work which now has regained subjects' attention.

The dependency of the Crisis Service call frequencies on the severity category of the caller provokes interest. Perhaps the severely disturbed individual is more troubled during fair dry weather because his personal problems are less diverted. The less disturbed caller, on the other hand, not only may not tend to use unstable weather as an escape, but may be hindered and frustrated by its interference with daily activities, of which he has more than the typical disturbed caller. Unstable warm weather may act as a catalyst in aggravating "ordinary" problems, but relieve the symptoms of more severely disturbed people. The direction of change of pressure appears to be the key factor

that differentiates the reaction of the severe caller from that of the ordinary caller. The student sample appears to behave like the ordinary caller, feeling less troubled during clearing weather with rising pressure. It is noteworthy that the Crisis Service callers seem to have been more affected by weather than the students. Further research is needed on the effect of weather on the symptom severity of sufferers of specific mental disorders. The outcome could result in a capability to improve mental health through patient migration to designated climatic regions.

There is no apparent reason for females to be less influenced by weather than males. Possibly the uncontrolled menstrual cycle dominated the "random noise" component of female data, hiding the weather effect more than for males. Past studies have suggested that women are more affected by wet or humid weather than men, but this finding may have been the case only when specific clothing or hair style differences between men and women prevailed most strongly.

The generally better male mood during relatively warm temperatures could reflect a desire to enjoy warm weather recreational activities. Either fewer women in this study shared the desire, or an equally strong desire was obscured by sampling error and menstrual cycle "noise."

The result that males were productive when their moods were generally high whereas women tended toward this to a lesser degree, if not sampling error, might be related to the antiquated and largely extinguished societal attitude toward work across the sexes – that productivity is more crucial to the self-esteem of males than females. On the other hand, it may imply that men need to be in better moods in order to be productive than do women.

Although rain has had no strong effect on the sample in this study, it can be expected to affect mood in two major opposing ways which may have offset one another: elevation of mood due to its diverting, change-of-pace aspect, or depression of mood due to its interference with outdoor activities. In much rainier climates, effects undoubtedly would be different.

Steadier male and total sample moods on days with some rain and overcast skies could have been due to a below-average number of activies undertaken on such days. Evening rain resulting in a mild lack of productivity and mildly high morale and nonirritability in males could be related to the diverting effect, especially since substantial evening rain occurred very few times within the 6-week study period.

Although a large number of results involving skew and absolute value of skew have been ignored, they are open to future study, which probably would require a larger subject pool and longer study period.

In conclusion, human moods and productivity appear to be affected by weather, although to a small extent compared with the total of all other sources of mood and productivity variability. In this study males showed a somewhat stronger average effect than females. Psychologically troubled people seem to be more affected by the weather than university students. Among troubled people, those suffering from relatively mild problems tend to be aggravated by warming, unstable, increasingly cloudy, humid conditions with falling barometric pressure. Those suffering from more severe mental disorders, by contrast, appear to be helped by these same weather conditions but aggravated by cool, sunny, stable weather with rising pressure. A tentative explanation for this has been proposed. The university students tend to react similarly to the troubled clients with mild problems.

Actual correlations between weather and the most affected mood variables appear to lie in the 0.15 to 0.40 range. With a larger time sample, a larger pool of subjects and a sensitive mood measurement instrument, narrower confidence limits for these correlations could be established, and the influence of weather on the moods and behavior of individual subjects could be examined more effectively.

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Appendix

The 36 Meteorological Variables

1 to 8: Temperature (T). All temperature data were normalized relative to the 89-year smoothed mean for the date, filtering out the rapid seasonal cooling trend during early autumn. An idea of the size of this trend is given by the mean temperatures at the starting date (19.2° C) and ending date (9.3° C) of the 6-week study.

1) Average temperature (avg T): mean of T at 08.00 h, 10.00 h, 12.00 h, 14.00 h, 16.00 h, 18.00 h, 20.00 h, and 22.00 h.

2) Morning temperature (AM T): mean of T at 08.00 h, 10.00 h and 12.00 h.

3) Late-day temperature (PM T): mean of T at 16.00 h, 18.00 h and 20.00 h.

4) Change from last day (ΔT last day): average T for day x minus that for day $x-1$.

5) Change from the last 3 days (ΔT last 3 days): average T for day x minus the mean of those for days $x-1$, $x-2$ and $x-3$.

6) Within-day temperature trend, morning (AM int ΔT): T at 12.00 h minus T at 08.00 h.

7) Within-day temperature trend, late-day (PM int ΔT): T at 16.00 h minus T at 20.00 h (usually a positive number).

8) Within-day temperature trend, total (int ΔT): mean of T at 16.00 h, 18.00 h and 20.00 h minus the mean of T at 08.00 h, 10.00 h and 12.00 h.

9 to 11: Relative humidity (RH).

9) Average relative humidity (avg RH): mean of RH at 09.00 h, 12.00 h, 15.00 h, 18.00 h and 21.00 h.

10) Change from last day (ΔRH last day): average RH for day x minus that for day $x-1$.

11) Within-day change in relative humidity (int ΔRH): mean of RH at 15.00 h and 18.00 h minus the mean of RH at 09.00 h and 12.00 h.

12 to 17: Percent of possible sunshine (PPS). Using a continuous graph of solar radiation in ly per min, the average radiation intensity over a 15-minute period centered at the time in question was visually estimated. This value was divided by that which would occur under the most clear, haze-free conditions possible at Champaign/Urbana on the data in question.

12) Average percent of possible sunshine (avg PPS): mean of PPS at 08.00 h, 10.00 h, 12.00 h, 14.00 h, and 16.00 h.

13) Morning percent of possible sunshine (AM PPS): mean of PPS at 08.00 h and 10.00 h.

14) Afternoon percent of possible sunshine (PM PPS): mean of PPS at 14.00 h and 16.00 h.

15) Change from the last day (ΔPPS last day): average PPS for day x minus that for day $x-1$.

16) Change from the last 3 days (ΔPPS last 3 days): average PPS for day x minus the mean of those for days $x-1$, $x-2$ and $x-3$.

17) Within-day change in percent of possible sunshine (int ΔPPS): mean of PPS at 14.00 h and 16.00 h minus the mean of PPS at 08.00 h and 10.00 h.

18 to 20: Barometric pressure (press). Pressure was not corrected to sea level or normalized relative to baseline diurnal fluctuations.

18) Average pressure (avg press): mean of press at 06.00 h, 12.00 h, 18.00 h and midnight.

19) Change from last day (Δpress last day): average press for day x minus that for day $x-1$.

20) Within-day change in pressure (int Δpress): press at 18.00 h minus that at noon.

21 to 35: Precipitation (rain). All precipitation during the study period was rain. Only rain occurring between 07.00 h and 23.00 h was considered. Data was parameterized in two ways: the actual rainfall amount recorded between two defined times, and the number of one-hour periods during which at least a given amount (trace or more, and 1.27 mm or more) fell.

21) Total amount (tot rain amt): total rainfall between 07.00 h and 23.00 h.

22) Total hours of any rain (tot h rain $\geq T$): number of hours between 07.00 h and 23.00 h during which at least a trace of rain fell (max = 16).

23) Total hours of substantial rain (tot h rain ≥ 1.27): as in variable (22), except for 1.27 mm of rain rather than a trace.

24) Morning amount (AM rain amt): total rainfall between 07.00 h and 12.00 h.

25) Morning hours of any rain (AM h rain $\geq T$): number of hours between 07.00 h and noon during which at least a trace of rain fell (max = 5).

26) Morning hours of substantial rain (AM h rain ≥ 1.27): as in variable (25), except for 1.27 mm of rain rather than a trace.

27) Afternoon amount (PM rain amt): total rainfall between noon and 17.00 h.

28) Afternoon hours of any rain (PM h rain $\geq T$): number of hours between 12.00 h and 17.00 h during which at least a trace of rain fell (max = 5).

29) Afternoon hours of substantial rain (PM h rain ≥ 1.27): as in variable (28), except for 1.27 mm of rain rather than a trace.

30) Evening amount (eve rain amt): total rainfall between 17.00 and 23.00 h.

31) Evening hours of any rain (eve h rain $\geq T$): number of hours between 17.00 h and 23.00 h during which at least a trace of rain fell (max = 6).

32) Evening hours of substantial rain (eve h rain ≥ 1.27): as in variable (31), except for 1.27 mm of rain rather than a trace.

33) Change from last day (Δh rain $\geq T$ last day): number of hours between 07.00 h and 23.00 h during which at least a trace of rain fell on day x minus the number of such hours on day $x-1$.

34) Change from last 3 days (Δh rain $\geq T$ last 3 days): number of hours between 07.00 h and 23.00 h during which at least a trace of rain occurred on day x minus the mean of the numbers of such hours on days $x-1$, $x-2$ and $x-3$.

35) Within-day change in rain (int Δh$\geq T$): number of hours between noon and 23.00 h during which at least a trace of rain occurred minus the number of such hours between 07.00 h and noon.

36: Wind.

36) Mean wind speed (wind): the visually estimated mean of a continuous wind speed graph between consecutive midnights.