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The Answer Is Blowing in the Wind

Weather Effects on Personality Ratings

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Abstract. This study examined the effects of weather on personality self-ratings. Single-assessment data were derived from the German General Social Survey conducted in 2008. For a subset of the participants (N = 478), official weather station data for the day a personality inventory was completed could be determined. Among these respondents, 140 (29%) completed the personality inventory on an unambiguously sunny day, 59 (12%) completed the measure on an unambiguously rainy day, and 279 (59%) completed the questionnaire on a day characterized by mixed weather conditions. Results revealed that self-ratings for some personality domains differed depending on the weather conditions on the day the inventory was completed. When compared with corresponding self-ratings collected under mixed weather conditions, ratings for the Big Five dimension of Openness to Experience were significantly lower on rainy days and ratings for Conscientiousness were significantly lower on sunny days. These results are suggestive of some limitations on the assumed situational independence of trait ratings.

Keywords: Big Five, weather, situational stability, situational specificity, personality assessment

Variations in weather (e.g., the degree of cloud cover, the amount of precipitation, barometric pressure, wind speed) affect a broad range of human behavior and experience. Varying weather conditions, for example, are related to changes in helping behavior (Cunningham, 1979), ratings of overall life satisfaction (Kämpfer & Mutz, 2013; although see Lucas & Lawless, 2013), stock trading activities (Dowling & Lucey, 2005; Hirshleifer & Shumway, 2003), and evaluations of politicians, political matters, and economic issues (Cohen, 2011; Mutz & Kämpfer, 2011).

Weather effects on mood have also been extensively studied. Whereas some studies have failed to reveal relationships between weather and mood (see Watson, 2000, pp. 91-102), others have reported small or inconsistent associations (e.g., Denissen, Butalid, Penke, & Van Aken, 2008; Keller et al., 2005; Kööts, Realo, & Allik, 2011). In related research, Klimstra and colleagues (2011) reported large individual differences in mood reactivity to weather. Although the sources of individual differences were not established in the Klimstra study, there are theoretical and empirical reasons to believe that personality traits might be relevant. Individuals high on the *Openness to Experience* trait domain, for example, are considered to be among those who are the most sensitive or reactive to environmental change (McCrae, 1983). In studies of personality associations with seasonal variations in mood, Openness significantly correlated with mood seasonality (Jang, Lam, Livesley, & Vernon, 1997; Murray, Allen, Rawlings, & Trinder, 2002) and distinguished persons with unipolar depression from those with seasonal affective disorder (Bagby, Schuller, Levitt, Joffe, & Harkness, 1996; Enns et al., 2006). These findings collectively suggest that persons with higher Openness scores experience greater drops in mood during winter months. *Neuroticism* is also an intuitive candidate for signaling a heightened sensitivity to environmental change, as this personality trait is partly defined by the experience of mood variability (Williams, 1993). Neuroticism, however, has been inconsistently associated with seasonal mood change (e.g., Jang et al., 1997; Murray et al., 2002), and findings on the moderating influence of Neuroticism on weather associations with mood have been equivocal (Denissen et al., 2008; Koots et al., 2011).

Research reviewed above has demonstrated that weather has a small or inconsistent influence on mood and behavior, and that some personality trait domains, most notably Openness and possibly Neuroticism, might index a sensitivity or reactivity to environmental change. A related question not explored to date, however, is whether variations in daily weather conditions *directly* influence personality ratings. Although personality traits are generally regarded as psychological qualities that contribute to a person's stable and unique patterns of thinking, feeling, and behaving (e.g., Cervone & Pervin, 2009), it is conceivable that ratings of personality traits might be influenced by a range of acute environmental events, particularly those that impact mood given the nonindependence of mood (state and trait) and personality (e.g., Meyer & Shack, 1989; Watson, 2000). Recent research, for example, has shown that major life events, such as the death of a partner or the loss of a job, can change an individual's standing on broad and presumably stable personality domains (e.g., Specht, Egloff, & Schmuckle, 2011). But what about relatively minor situational variations, such as day-to-day weather conditions? Such situational conditions are usually assumed not to affect personality ratings

(cf. Allport & Odbert, 1936), but this proposition has not to our knowledge been previously evaluated in relation to weather. The present study explored the direct effect of daily weather conditions on personality ratings in a large community sample. For this sample official weather station data were available for the day on which a self-report measure of the Big Five personality domains was completed. If weather is subsequently shown to impact judgments about one's personality, an implication would be that responses to personality measures are not independent of the conditions under which they were assessed.

Method

Sample

Our analyses are based on data from the German International Social Survey Programme 2008 (ISSP), which was assessed conjointly with the German General Social Survey (ALLBUS; http://www.gesis.org/allbus). The ALLBUS is based on a large representative sample (N = 3,469) of the German adult population (age > 18) who resided within private accommodations in Germany. Foreigners able to complete the questionnaire in German were included in the sample. The sample was drawn in a two-stage design from official registers of inhabitants kept by municipalities throughout Germany, and all interviews were conducted between March and August 2008. The participation rate for the ALLBUS survey was 40%. Details of the sampling procedure and sample composition are presented in the technical report of ALLBUS 2008 (Wasmer, Scholz, & Blohm, 2010).

While the ALLBUS survey is conducted in the form of a face-to-face interview, the ISSP component was administered as a computer-based questionnaire completed by study participants immediately after the personal interview. The interviewer remained in attendance while participants completed the survey. Participation was voluntary and not financially rewarded. The ALLBUS 2008 survey is a suitable data set for testing the influence of weather on selfratings for two reasons. First, the survey documents the day of the interview. Second, based on the administrative district *(Regierungsbezirk)* and the township population recorded in the ALLBUS data set, the city where the interview was conducted could be reconstructed for a portion of the sample that resided in metropolitan areas within Germany (14%; $N = 478$). The procedures used to make these determinations are described below. When this selected subsample was compared with the subsample for whom township could not be determined, those in the selected subsample were significantly higher educated and more likely to live in single person households. With regard to ratings on the personality measure used in this research (described below), selected respondents also scored slightly higher on Openness to Experience and slightly lower in Agreeableness and Conscientiousness compared to interviewees not selected. There were, however, no significant differences in age, sex, and income between the interviewees included and those not included in this study.

Measures

The Ten-Item Big Five Inventory (BFI-10)

The BFI-10 (Rammstedt & John, 2007) is an abbreviated version of the well-established Big Five Inventory (BFI; John, Donahue, & Kentle, 1991; for the German version see Lang, Ludtke, & Asendorpf, 2001; Rammstedt, 1997). Personality dimensions assessed with the BFI-10 are Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to Experience. Each of these personality domains are assessed with 2 items from the standard 44-item BFI, with item pairs keyed in opposing directions.

In accordance with the response format used throughout the ISSP questionnaire, all items used 5-point Likert-type response options ranging from *fully agree* to *fully disagree*. Although this response scale differs in its orientation from the standard BFI-10 format, a previous study showed that reversing the direction of the response scale does not change the quality of the ensuing responses (Rammstedt & Krebs, 2007).

Weather Conditions

Local weather conditions on the day of the interview were established in accordance with official weather data obtained from the German National Meteorological Service. Two common weather indicators were used in the present study: total sunshine duration in hours and total precipitation in millimeters per square meter. Based on this information, three dummy variables were constructed, which identify (a) respondents who were interviewed on days on which the weather was unambiguously sunny (N = 140), (b) respondents who were surveyed on days on which the weather was unambiguously cloudy and rainy (N = 59), and (c) respondents who were surveyed on all other days, which were characterized as ''mixed weather days'' (N = 279). We regarded all days as ''sunny days'' on which the sun shone for over 7 hr and on which no precipitation was measured. Likewise, all days with relatively high amounts of precipitation, that is at least 3 mm/m^2 and less than 3 hr of total sunshine, were classified as ''rainy days.'' The combination of both weather indicators - sunshine and precipitation - is necessary to ensure that our measure for a ''sunny day'' and a ''rainy day'' does not include days with alternating sunny and rainy periods.

Regional Information

Because weather conditions in a given territory can vary significantly from city to city and from region to region, weather data can only be definitively linked with survey data at the local level. The ALLBUS includes information on the administrative district and on the size of the population of the town or city in which the respondent lives. Combining these data allowed us to identify several major German cities. For example, the federal state of Hesse has only one city - Frankfurt am Main - with more than 500,000 inhabitants. Other major cities, like Berlin, Munich, or Stuttgart, can be identified in a similar way. Respondents from these cities were considered for study inclusion provided that a third condition was fulfilled: the availability of official weather station data for that city from the German National Meteorological Service. The resulting sample that met each of these three conditions included 478 respondents from 11 different major German cities. These respondents were interviewed on 134 different survey days. On these days sunshine duration averaged at 6.1 hr (SD = 4.2) and precipitation averaged at 1.9 mm/m^2[1] (SD = 3.1). The 11 cities selected differed slightly in their mean weather parameters on the survey days, with an average sunshine duration ranging from 4.8 hr in Saarbrücken to 6.8 hr in Stuttgart and average precipitation ranging between 0.9 mm/m^2 in Hanover and 3.5 mm/m^2 in Nuremberg.

Data Analysis

To estimate the effects of weather on responses to Big Five item sets, two related analytic procedures were used: ordinary least-squares (OLS) regression and multilevel modeling (MLM). An assumption underlying the OLS analyses is that each respondent represents an independent observation. It is conceivable, however, that residents from the same city are more alike than residents from different cities. For example, those from the same city might be exposed to weather features that are somewhat unique relative to other locations. Consequently, MLM methods were also used to control for the possibility that geographic location, specifically the cities within each participant resided, could be a factor that influenced responding to Big Five items independently of weather as operationally defined in this study.[1] In all MLM-based analyses, participants were nested within cities (for an overview on MLM, see Hox, 2010). Both OLS and MLM analyses were conducted twice, in the first instance to compute unadjusted effects (i.e., simple model) and in the second instance to derive adjusted effects after control of relevant socio-demographic variables and the month of the year during which the interview was conducted (i.e., adjusted model). All analyses were performed with IBM SPSS 21.

Results

Table 1 presents means and standard deviations for each Big Five personality domain separately for the three weather conditions. Corresponding effect sizes and independent t-test comparisons for personality ratings as a function of weather condition, namely sunny or rainy weather versus mixed weather as well as sunny versus rainy weather, are also presented. Cohen (1988) offers guidelines for interpreting the magnitude of effects, with $d < .20$, $d = .50$, and $d > .80$ considered small, medium, and large effects, respectively. Consistent with weather-related findings from earlier studies, observed effect sizes presented in Table 1 were generally small in magnitude. In only two *t*-test comparisons, significant mean differences were noted, each of which were associated with medium effect sizes. These two significant comparisons were for the negative effects of rainy weather on Openness (—.29) and sunny weather on Conscientiousness (—.21) when referenced to mixed weather. Another medium effect was observed for the negative effect of rainy weather compared to sunny weather on Extraversion (—.23). This effect, however, did not reach conventional level of significance ($p = .06$), most probably due the small sample sizes in these two groups.

[1]Personality ratings as well as weather conditions varied only to a small degree with the region of residence in the present research. Intraclass correlations (ICCs) for personality ratings were .00 (Extraversion), .02 (Openness and Conscientiousness), .04 (Agreeableness), and .05 (Neuroticism). ICCs for the weather variables were .00 (sunshine) and .04 (rain).We nonetheless present findings from OLS and MLM analyses. Although MLM-based methods are most appropriate for multilevel data in personality research (Nezlek, 2008), we recognize that researchers who wish to replicate aspects of our study may be unable to assess multiple townships, in which case our OLS findings might be the most appropriate reference for comparison purposes.

Table 1. Means and standard deviations of personality traits according to weather condition

	Rainy weather			Sunny weather			Mixed weather			Rainy vs. mixed		Sunny vs. mixed		Rainy vs. sunny	
Big Five dimension	*M*	*SE*	*SD*	*M*	*SE*	*SD*	*M*	*SE*	*SD*	*d*	*t*	*d*	*t*	*d*	*t*
Extraversion	3.12	.12	.89	3.33	.08	.95	3.25	.06	.94	−.14	−1.00	.09	0.82	−.23	−1.49
Agreeableness	3.09	.09	.67	3.14	.07	.79	3.21	.05	.82	−.15	−1.20	−.09	−0.85	−.07	−0.46
Conscientiousness	4.01	.08	.64	3.95	.06	.75	4.11	.04	.73	−.14	−1.06	−.21	−2.08*	.09	0.57
Neuroticism	2.61	.10	.78	2.63	.07	.88	2.53	.05	.84	.10	0.71	.11	1.11	−.02	−0.16
Openness	3.36	.12	.90	3.52	.08	.89	3.60	.05	.83	−.29	1.89*	−.10	−0.89	−.18	−0.15

Notes. *M* = mean; *SE* = standard error; *SD* = standard deviation; *d* = Cohen's *d*; *t* = *t*-test value; *$p < .05$.

Table 2 shows the results of OLS and MLM analyses with the Big Five domain scores as predicted variables and weather conditions as predictors. Outcomes from these analyses, both non-adjusted and adjusted, along with corresponding effect size data presented in Table 1, were generally consistent. Most comparisons did not reveal significant differences in personality ratings as a function of weather conditions. Openness self-ratings, however, varied with weather, whereby scores on this dimension were significantly lower on rainy days when referenced to ratings collected on mixed weather days. This pattern was significant in non-adjusted and adjusted OLS models and for the adjusted MLM model, but just failed to reach conventional levels of significance in the non-adjusted MLM model (p = .07). Importantly, the magnitude of rainy weather effects on Openness ratings as referenced by unstandardized coefficients was highly similar in each analysis (range: —.22 to —.26). Openness ratings collected on sunny days, however, were not significantly different from ratings collected during mixed weather days, nor were Openness ratings significantly different on sunny and rainy days.

Table 2. Effects of weather conditions on Big Five Personality traits

	Simple models				Adjusted models[a]			
	OLS		Multilevel		OLS		Multilevel	
Big Five dimension	*b*	*p*	*b*	*p*	*b*	*p*	*b*	*p*
(1) Extraversion								
Sunny vs. mixed weather	.08	.40	.09	.33	.02	.86	.02	.84
Rainy vs. mixed weather	−.13	.34	−.12	.37	−.25	.09	−.25	.08
Sunny vs. rainy weather	.21	.15	.21	.14	.26	.10	.27	.09
(2) Agreeableness								
Sunny vs. mixed weather	−.08	.35	−.03	.75	−.04	.69	−.03	.69
Rainy vs. mixed weather	−.12	.29	−.08	.47	−.03	.78	−.03	.77
Sunny vs. rainy weather	.04	.72	.06	.65	−.00	.99	−.00	.99
(3) Conscientiousness								
Sunny vs. mixed weather	**−.16**	**.04**	**−.15**	**.04**	**−.22**	**.01**	**−.22**	**.01**
Rainy vs. mixed weather	−.10	.33	−.09	.39	−.05	.65	−.05	.64
Sunny vs. rainy weather	−.06	.62	−.06	.57	−.17	.16	−.17	.15
(4) Neuroticism								
Sunny vs. mixed weather	.10	.26	.09	.33	.13	.16	.13	.15
Rainy vs. mixed weather	.08	.50	.06	.61	.01	.96	.01	.96
Sunny vs. rainy weather	.02	.89	.02	.87	.12	.38	.12	.36
(5) Openness								
Sunny vs. mixed weather	−.09	.33	−.06	.48	−.02	.82	−.02	.84
Rainy vs. mixed weather	**−.25**	**.04**	−.22	.07	**−.26**	**.04**	**−.26**	**.04**
Sunny vs. rainy weather	.16	.22	.16	.23	.24	.10	.24	.08

Notes. Unstandardized coefficients (*b*). Bold coefficients are significant at $p \leq .05$. [a]The adjusted models account for the city of residence, age, sex, education, employment status, migration background, marital status of the respondent as well as the month of interview. The variance in personality ratings uniquely explained by the weather variables is .007 for Extraversion ($p = .20$), .000 for Agreeableness ($p = .91$), .014 for Conscientiousness ($p = .03$), .004 for Neuroticism ($p = .36$), and .008 for Openness ($p = .13$) based on the respective OLS-model. A similar pattern of findings was obtained based on MLM modeling.

Neither rainy nor sunny weather had a significant influence on Neuroticism, Extraversion, or Agreeableness domain scores in any analysis. An effect for sunny weather, however, was observed on Conscientiousness scores. In non-adjusted and adjusted OLS and MLM models, sunny weather was significantly associated with lower Conscientiousness scores when compared with corresponding domain ratings collected under mixed weather conditions. The magnitude of the sunny weather effect on Conscientiousness was —

.15 and —.16 for unadjusted OLS and MLM models, respectively, and —.22 for each adjusted model. Conscientiousness ratings collected on rainy days, however, were not significantly different from those collected on sunny days or days characterized by mixed weather conditions..

Due to the fact that only two items per personality domain were assessed, we evaluated if the observed effects associated with Openness and Conscientiousness scale scores reported in Table 2 were largely determined by only one individual item by means of item-level post hoc analyses. Regression analyses similar to those based on overall domain scores were repeated, with single items from the BFI-10 Openness and Conscientiousness scales substituted for domain scores as the predicted variables. For both Openness and Conscientiousness, post hoc analyses revealed consistency in the magnitude of effects associated with each predicted variable, with effects associated with single items being almost identical to those observed for domain scale scores.

Based on theory and earlier research that suggests individuals who score highly on the Openness domain are more reactive to environmental change, we also compared beta coefficients based on participants' level of Openness separately for sunny and rainy conditions in relation to the remaining four personality domains. For this analysis, respondents with Openness scores > 4.0 were considered high in Openness (N = 209), and individuals' with scores below this threshold categorized as low on this dimension (N = 269). When beta coefficients for sunny and rainy days were compared as a function of participants' level of Openness and tested for the significance of their differences based on Fisher r-to-z transformation methods, results indicated no significant differences in responses to sunny weather as a function of Openness level. For rainy weather, however, individuals high on Openness were generally more reactive than those low on this dimension. Differences in beta values as a function of Openness ranged between .05 for Extraversion and .31 for Conscientiousness, with the mean value across all four domains being .19. These differences achieved statistical significance in two instances: for Agreeableness ($p < .05$) and Conscientiousness ($p < .01$).

Discussion

The present study set out to investigate the situational independence of self-ratings on personality questionnaire items. Specifically, we investigated the extent to which weather conditions impacted responses to personality items and thus the interpreted standing of the individual on the personality dimensions assessed. Findings from the present research demonstrate that personality self-reports do occasionally vary to a small degree with objective weather conditions. Respondents perceived themselves as lower on Openness to Experience on rainy days and lower on Conscientiousness on sunny days compared to days with mixed weather. The observation that Conscientiousness scores were lower on sunny days was an unanticipated finding and warrants additional investigation. Exposure to extraordinarily good and sunny weather might have an acute disinhibiting effect, for example, whereby people on such days have a greater propensity to view themselves as being more easy-going and spontaneous and less disciplined and dutiful.[2]

Sensitivity to environmental change has been suggested to be a feature of Openness (McCrae, 1983; Murray et al., 2002). Secondary findings from the present research further suggest that respondents who score high on the Openness dimension are more reactive to rainy but not sunny weather conditions as reflected in responses to items that assess some personality dimensions. Overall, findings from the present research are consistent with the view that individuals who score highly on the Openness domain are sensitive or reactive to environmental change (McCrae, 1983).

From a methodological perspective, our results indicate that personality self-reports, at least for some domains, are significantly albeit modestly affected by acute environmental events such as current weather conditions, and that individuals high in Openness might be especially reactive to some weather events. Such findings could suggest that the *process* of personality assessment is sensitive to some situational influences that, in turn, impact the validity of assessment through the introduction of measurement error. Alternatively, one could argue that such environmental events exert influence on variable state components associated with stable personality traits (cf. Meyer & Shack, 1989). In these latter instances, variable ratings of personality attributes related to environmental events would be valid indicators of both state variability *and* trait stability. Although an individual might be highly open to experience generally, for example, acute weather events might influence state self-perceptions of Openness or associated attributes to a small or moderate degree, thus accounting for variability in self-reports when assessed under different environmental conditions.

Findings from the present research must be viewed in conjunction with some study limitations. First, significant effects, when observed, were relatively small and would have failed to reach conventional levels of significance had the critical alpha level been adjusted for the number of tests conducted. When weather effects on mood ratings and behavior have been observed in past research, however, observed effects were also generally small. Second, data collection was limited to spring and summer months (March

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[2] Our analyses, however, only revealed significant associations with one particular weather condition – rain in the case of Openness to Experience and sunshine in the case of Conscientiousness – whereas the opposing weather category was statistically unrelated to selfratings for each of these personality domains. Our findings, therefore, do not necessarily imply that the continuum of weather conditions and personality self-ratings are positively or negatively associated in a linear way. Rather, weather and personality self-ratings might be associated in a U-shaped way whereby extremely good and extremely bad weather influence self-ratings in the same direction.

through August). The survey's timeframe, therefore, did not include seasons where rainy weather is most likely, which may, in turn, have attenuated effects associated with rainy weather. Similarly, the relatively small proportion of participants who completed the survey on rainy days also reduced our ability to detect small effects with this sample. The slight tendency of respondents to describe themselves as slightly more extraverted on sunny compared to rainy days, for example, is an unexpected finding, and should be investigated further with a larger sample and with greater balance in the number of personality ratings collected under each weather condition than was the case in the present research. Similarly, the absence of significant weather effects on Neuroticism, may, in part, be a consequence of not assessing personality attributes during fall and winter seasons. Signs and symptoms associated with seasonal affective disorder, for example, are often most
evident during winter months (Lurie, Gawinski, Pierce, & Rousseau, 2006). Third, our emphasis on accurately linking weather data to region and city resulted in a substantial reduction of available cases so that the total number of cases investigated per condition was comparatively low. In addition, this reduction altered the representativeness of the sample with reference to the German adult population (i.e., a greater bias toward large city residents). Fourth, we used the BFI-10, which utilizes only two items to assess each of the Big Five personality domains. Abbreviated Big Five measures such the BFI-10 (Rammstedt, 2007; Rammstedt & John, 2007) and the Ten-Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) have a substantially narrower content range than comparable full- length inventories and, consequently, might be less sensitive to transient changes in ratings related to environmental conditions. To the extent that variance in personality ratings was attenuated as a result of our use of the BFI-10, it is plausible that even larger effects of weather on personality ratings might be observed with similar inventories that contain more item representatives for each personality domain. When compared to their full-length counterparts, ultra brief Big Five measures are also less reliable, over-emphasize representation of some facets of broadband domains at the expense of others, and demonstrate lower correlations with external criteria including other Big Five inventories (Gosling et al., 2003; Rammstedt & John, 2007). Replication of the present research with full-length Big Five measures is therefore needed to establish the robustness of observed findings and to perhaps isolate facets within domains that are most vulnerable to weather-related influences. Fifth, this study was based on a cross-sectional design. Within-subject designs in which the same participants provide personality ratings on sunny and rainy days would allow for firmer conclusions about weather effects on personality ratings. Such designs would also allow for tests of state mood mediation of weather effects on personality ratings. Finally, although we employed rigorous and verifiable methods for categorizing weather conditions on days when personality assessments were collected, we were nonetheless unable to ascertain how much direct exposure participants had to the day's weather.

In conclusion, the present study demonstrated that personality self-ratings are likely affected to some degree by the weather and possibly other conditions under which assessments are performed. Such situational factors would include meteorological factors such as the season, ambient temperature, and humidity levels. Other naturally occurring situational features could also be examined for their influence on personality ratings, such as the location where personality assessments are obtained (e.g., indoors vs. outdoors) and the time of day when attributes are assessed (morning, afternoon, or evening). In situations where the accurate assessment of personality is critical, repeated measurements might be taken under naturally varying conditions. Research on situational factors that influence personality ratings might also aid the future development of assessment measures or methods that are less sensitive to transient environmental events.

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