

On the Sunny Side of Life: Sunshine Effects on Life Satisfaction

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Abstract This paper seeks to analyze the influence of the weather on a person's self-reported life satisfaction. On a theoretical level, it is claimed that 'nice' weather can improve the affective well-being of a person. Given this, it is argued that affects can, in turn, have an impact on that person's general assessment of his or her life. In particular, it is expected that people would report a higher life satisfaction on days with unambiguously 'nice' weather. Data from three German large-scale surveys are used to test empirically to what extent self-reported life satisfaction is determined by the weather. All in all, the results are mostly consistent with the initial hypothesis. In all three samples those respondents surveyed on days with exceptionally sunny weather reported a higher life satisfaction compared to respondents interviewed on days with 'ordinary' weather. In two out of three samples, this difference was statistically significant. Hence, the supposed sunshine effect on peoples' life satisfaction does indeed exist. Implications of these findings are discussed in a conclusion.

Keywords Well-being · Life satisfaction · Happiness · Mood · Weather · Sunshine · Climate conditions

1 Introduction

For over 20 years, psychologists have discussed to what extent a person's assessment of his or her life is influenced by situational and context-specific conditions. These debates began with a series of experiments conducted by Schwarz and his colleagues (Schwarz and Clore 1983; Schwarz et al. 1987). According to Schwarz et al. respondents' satisfaction with their lives increased upon witnessing a victory of their national team in a soccer world cup match. In contrast, respondents whose national team only reached a draw were less satisfied with their lives shortly after the game. Furthermore, respondents who were interviewed in a dirty, overheated, malodorous and noisy room reported a lower satisfaction

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with their lives compared to respondents who evaluated their lives in comfortable and spacious surroundings. In a third experiment, they identified another situational factor that influenced general life satisfaction: Students who—immediately before being interviewed—found an apparently overlooked coin at the copying machine in the university library assessed their lives more positively than students who did not have such ‘good fortune’. These results are highly important for research on life satisfaction, since they raise major doubts about whether an individual’s assessment on happiness can be interpreted as a reliable and valid indicator of their quality of life. Are self-evaluations on life satisfaction in fact valid read-outs of a relatively constant internal state of subjective well-being? Or is the underlying judgment highly affected by fortuitous situational conditions, so that a person’s general life satisfaction may change significantly from one moment to another?¹

This paper seeks to contribute to these debates by analyzing the influence of one situational factor in greater detail: the weather. We investigate whether or not the weather conditions on the day of the interview affect a person’s evaluation of his or her life. Do people report greater happiness with their life on days with ‘nice’ weather? And if they do, how can such a weather effect be explained on a theoretical level?

(1) Only a few studies are published to date that estimate the influence of weather and climatic conditions on a person’s life satisfaction: Some of them investigate the consequences of *long-term* climate changes for ecosystems, economies and—last, but not least—peoples’ well-being (Frijters and van Praag 1998; Rehdanz and Maddison 2005; Becchetti et al. 2007). In these studies, it is argued that climatic conditions may impact an individual’s psychology and the assessment of their quality of life. Commonly, these studies try to explain differences in the mean level of life satisfaction between nation states with different climate parameters: e.g. a country’s annual mean temperature, the annual precipitation amount, the mean temperature of the hottest and coldest month of the year, the number of days with rainfall or fog per year. Findings from these studies show that climatic differences between nation states are strongly associated with the average life satisfaction of a country’s population. On the one hand, extreme meteorological conditions, like very high or low temperatures, a high amount of rainfall or extreme aridity, have a negative influence on life satisfaction. On the other hand, moderate weather with plenty of sunshine and marginal amounts of rain are associated with a more positive assessment of the quality of life.

(2) In a recent analysis, Guven (2009) detects that *medium-term* weather conditions can also influence a person’s life satisfaction. His findings show that happiness increases with the regional sunshine deviation, which is calculated as the difference between the preceding 10 days weighted average of regional sunshine and the average of this preceding 10 days average over the last 60 years. Life satisfaction should thus increase whenever the most recent days were marked by considerably greater sunshine compared to the same period in the years before. Contrarily, if the sun shines less often (as one may expect from the previous meteorological patterns over the years), life satisfaction is predicted to decline during such a phase.

¹ Whereas personality psychologists mostly argue in favour of the first position, the second point of view was mainly investigated by scholars who represented the social cognition tradition. This latter school of thought tested, in particular, how ‘technical’ aspects of questionnaire design and of the interview situation influenced self-reported life satisfaction (item order effects, interviewer effects, etc.). These studies mostly documented consistent, but small effects on self-reports of life satisfaction (Schimmack and Oishi 2005). Furthermore, some studies investigated the relevance of mood-inducing events on peoples’ life satisfaction. The experiments by Schwartz cited at the outset of this paper are one example for this kind of research.

(3) Finally, only one study has been conducted to date in which the *short-term* effect of weather on a persons' life satisfaction was assessed. This study by Schwarz and Clore (1983) was part of the experiments that we mentioned at the outset of this paper. Respondents were either interviewed on a sunny day or on a rainy day. Those who were questioned on sunny days reported a significantly higher level of life satisfaction compared to respondents whose interview took place on a rainy day. Up to now, this finding is heavily cited in the literature on subjective well-being and the alleged effect of weather on life satisfaction has almost become commonplace in today's scholarly literature (Diener 1984; Schwarz and Strack 1991, 1999). However, this seemingly common knowledge rests on somewhat shaky ground as the original study is based on a rather small sample of 84 respondents² and—to the best of our knowledge—has not been replicated since.

Our paper proceeds as follows: Firstly, two interrelated steps of argumentation explain how weather conditions may influence a person's satisfaction with his or her life. We claim that 'nice' weather can have a positive effect on the affective well-being of a person during his or her evaluation. Secondly, we argue that affects can, in turn, have an impact on that person's general assessment of his or her life. After this theoretical reasoning, we use survey data to test to what extent self-reported life satisfaction is in fact determined by the weather. We explain the design of our analysis and present the main findings of our research. The results indicate that a person's life satisfaction does, in fact, depend to some degree on the weather. On average, those respondents who were interviewed on days with particularly 'nice' weather reported a higher satisfaction with their lives. Implications of these findings are discussed in a conclusion.

2 How Can the Weather Influence a Person's Life Satisfaction?

In a first step, we argue that weather conditions can influence people's affective well-being. Secondly, we reflect on the influence of such momentary affective well-being on the cognitive assessment of one's own life. By linking both arguments, it can be concluded that a person's life satisfaction may very well depend on the given weather, at least to a small degree.

2.1 How Does the Weather Influence Affective Well-Being?

The effects of the weather on people's affective well-being, especially on their moods, have already been proven in many studies.³ In several studies, seasonal mood fluctuations were analyzed. As these fluctuations can become particularly strong among some individuals, they are discussed within the scope of *Seasonal Affective Disorder* (Rosenthal

² Participants in this study were put into three test conditions groups, so that 28 respondents were questioned per test condition. It seems noteworthy, though, that weather-induced differences in life satisfaction, as reported by Schwarz and Clore, are insignificant in two of the three test conditions. Strictly speaking, the popular belief that weather can affect a persons' life satisfaction is based only on one tiny study with solely 28 respondents.

³ Affective well-being consists of both pleasant and unpleasant affects. Affects, in turn, consist of moods as well as emotions. Emotions differ from moods: "Because emotions arise from ongoing, implicit appraisals of situations with respect to their implications for one's goals, they have an identifiable referent, a sharp rise time, and limited duration. These characteristics distinguish emotions from moods, which lack a clear referent, may come about gradually, may last for an extended time and are often of low intensity" (Schwarz 2011: 8).

et al. 1984) or *Seasonal Depression* (Canbeyli 2010). According to these studies, typical mood fluctuations are observed during the course of the year: In the cold and dark winter months, depression is more prevalent, while in spring and summer depressive states decline. Various aspects of the weather, such as temperature, cloudiness and air pressure, but especially the amount of sunshine, are linked to these seasonal fluctuations in people's moods (see, for example, Jacobsen et al. 1987; Harmatz et al. 2000; Magnusson 2000; Winkler et al. 2002; Oyane et al. 2008).

Furthermore, other scholars point to changes in affective well-being as a result of short-term weather variations. For example, Denissen et al. (2008) demonstrate that a variety of weather parameters can influence a person's mood. Especially the amount of sunshine at the time of the interview is of major importance, as more sunshine considerably reduces negative affects. These findings have recently been confirmed by Murray et al. (2010), who discovered that negative affects decrease on sunny days.⁴ Moreover, experiments show that even short periods of sunlight—in most cases of only a few hours—are sufficient to improve the mood of a person and to reduce any depressive symptoms. The same effect accompanies artificial sunlight. If people are exposed to artificial sunlight, this leads to an improvement in affective well-being in both depressive and healthy subjects (Jacobsen et al. 1987; Kripke 1998; Leppämäki et al. 2002; Canbeyli 2010). This positive influence of sunlight on people's moods is explained by a light-induced increase in serotonin in the brain. Serotonin is known as a 'happiness hormone'. It is associated with activity and initiative, positive mood, sexual desire, well-being and even with euphoric states (Przuntek and Müller 2005).⁵ This knowledge is used for the clinical treatment of depression by means of light therapy. If a depressive patient is exposed to an hour of artificial sunlight in the morning or the early evening, the level of serotonin rises considerably and this in turn improves his or her mood (Rosenthal et al. 1984, 1993; Even et al. 2008). In view of these findings, it seems obvious that affective well-being is influenced by weather conditions and, in particular, may vary with sunshine. The next section explains how these affects, in turn, influence life satisfaction ratings.

2.2 How Does Affective Well-Being Influence Life Satisfaction?

The prevalent view among psychologists is that affective and cognitive well-being are two distinguishable analytical constructs, and that life satisfaction ratings are supposed to measure cognitive well-being (Diener et al. 1999; Schimmack 2008). Like any other evaluation, life satisfaction ratings underlie a judgment process. In this process, people reflect on the relevant and accessible information about their lives, like living conditions, social relations or job satisfaction. However, there are no objective standards for the evaluation of this information and therefore these judgments depend on multiple internal and external standards of comparison, as well as the person's character and individual personality. Additionally, feelings and moods at the time of the evaluation can be used as a

⁴ In another study, Keller et al. (2005) demonstrate that warm and sunny weather only improves a subject's mood if this person had spent more than 30 min outdoors. Thus, the sunshine effect on mood is positive, but only for those who are directly exposed to the weather. Contradictory results are reported by Watson (2000). In his research among students from Texas and Japan, no significant correlations between weather and moods are found. Neither sunshine nor air pressure, temperature or precipitation influenced the mood of the students.

⁵ Parker and Tavassoli (2000) argue that in climate zones with lower average sunshine, the level of serotonin has to be increased by other means. They can show, for example, that people consume more alcohol, coffee, chocolate and cigarettes in these regions.

source of information as well.⁶ Affective states can influence life satisfaction ratings in two ways.

(1) On the one hand, psychologists investigate the influence of a person's *prior* affects on their current life satisfaction. Supporters of this 'hedonistic position' assume that a person's life satisfaction is a result of recently experienced affects. Accordingly, the frequency and intensity of positive and negative affects during the preceding few days or weeks are measured and used as a predictor of current life satisfaction. The majority of these studies indeed show a positive correlation between pleasant affects and life satisfaction and a negative correlation between unpleasant affects and life satisfaction. Consequently, the affective balance can be seen as an important source of information for the assessment of one's life (Pilcher 1998; Schimmack et al. 2002a, 2002b; Kuppens et al. 2008). In post-modern and individualistic societies, this association between affects and life satisfaction is even stronger compared to more traditional and collectivistic countries (Suh et al. 1998).

(2) On the other hand, psychologists analyze the significance of *current* affects on a person's life satisfaction. Here again, it is assumed that positive affective well-being increases self-reported life satisfaction, while negative affects decrease life satisfaction. Yardley and Rice (1991) investigated the influence of prior life satisfaction, prior mood and current mood on current life satisfaction. They can demonstrate that a person's life satisfaction can best be explained by his or her current mood. The authors, however, do not explain how exactly current moods impact life satisfaction. Nevertheless, three mechanisms can be found in the literature which can explain the influence of current affective well-being on life satisfaction: (a) affect-congruent perception (b) affect-congruent memory and (c) affect-congruent evaluation. As the next sections explain in more detail, perception, memory and evaluation of information depend on the person's affective well-being at any given point in time. This concerns the perception, memory and evaluation of information about one's own life, too.

(a) The influence of affects on *perceptions* has been proven in many studies. Generally, positive affects lead to an increased awareness of positive information, whereas negative affects lead to increased awareness of negative information (Mogg and Bradley 1998; MacLeod 1999; Tamir et al. 2006; Tamir and Robinson 2007; Robinson and Compton 2008). It is argued that positive affects broaden a person's focus of attention and improve the ability to direct attention to positive aspects of a given situation. In addition, this goes hand-in-hand with a more effective suppression of negative information (Compton et al. 2004). In sum, sad people are more aware of negative information in their surroundings, while people in a happy and bright mood would perceive the same situation differently and regard it as more positive.

(b) Affect-congruent perception is supplemented by affect-congruent *memory*. In this regard, numerous studies on the "affect-priming" hypothesis are highly instructive. This hypothesis points out that the accessibility of information in our memory varies with affective states. It is argued that memory contents always have an affective component. Information that fits to the current mood can be more easily recalled and made accessible. People in a positive mood are able to remember more information with a positive shade and they can bring this information to mind more quickly (MacLeod and Campbell 1992; Mayer et al. 1992; Robinson 2004; Isen 2008; Robinson and Compton 2008). Hence, Schwarz (2011: 3) concludes: "From this perspective, positive (negative) aspects of life are more likely to come to mind when we are in a happy (sad) mood, resulting in mood-congruent judgments."

⁶ For a review of different approaches used to explain life satisfaction, see Diener (1984) or Diener et al. (1999).

(c) In line with the so-called “mood-as-information” hypothesis—which was expanded into the “feelings-as-information” theory—it can finally be argued that in any *judgment* process people *inter alia* rely on their emotions and moods (Schwarz and Clore 1983; Tversky and Griffin 1991; Clore and Huntsinger 2007; Schwarz 2011). When assessing a situation or an issue as, for example, their satisfaction with life, they do not only reflect on cognitive information, but on affective states as well. The impact of current moods on the assessments depends on a variety of factors, namely on the mood itself, on the issue to be assessed and on the person making the evaluation (Greifeneder et al. 2010). Thereby, people try to include only those affects in their judgment that are either closely related to or caused by the issue to be assessed. According to Schwarz (2011), these affects can be regarded as integral feelings. However, as affects may have various origins, it is a difficult undertaking only to take account of these integral feelings. Affects that, for example, may be induced by the weather cannot be faded out easily during the assessment of one’s life and thus may lead to a positively (or negatively) biased assessment (Schwarz 2011). Furthermore, the impact of current moods on the assessment of an issue increases when the definition of the assessment criteria is unclear, when insufficient information is available, when no pre-stored assessment is available (which might be recalled) and when subjects have little motivation to assess the issue correctly and comprehensively (Schwarz and Strack 1999; Greifeneder et al. 2010; Schwarz 2011).

The assessment of a person’s life can therefore be influenced in several ways by affective states. First, prior affects can have an influence on life satisfaction by laying the groundwork for the assessment of one’s current life. Secondly, current affects—independent of their previous development—can have an impact on life satisfaction by influencing perception, memory and the evaluation of information. Affect-congruent perceptions make people notice especially that information about their lives which fits to their current affective well-being. Affect-congruent memory causes them to remember rather that information about their lives which corresponds to their present mood. And finally, when assessing their lives, people may directly rely on current affective well-being without further reflection on the actual origins of these affects. The result is always the same: The life satisfaction judgment of a person can be, at least to some degree, a result of their affective state.⁷

2.3 Guiding Assumptions for the Empirical Analyzes

Some of the aforementioned studies about climatic and seasonal changes in subjective well-being analyze various aspects of the weather. They show that sunshine duration, precipitation and mean temperatures can all have a specific impact on subjective well-being.⁸ However, the causal mechanisms that lead to a change in well-being often remain rather opaque. How could it be explained, for example, that a large amount of precipitation

⁷ Both the “affect-priming”-hypothesis and the “mood-as-information”-hypothesis have been proven many times, for example, in the context of the evaluation of probabilities and risks. In a study by Johnson and Tversky (1983), subjects who were in a bad mood overestimated the probability of death as a result of illness or natural disaster, while respondents in neutral moods came to fairly adequate estimations (see also Mayer et al. 1992; for more recent reviews Forgas 2008; Blanchette and Richards 2010).

⁸ Among others, this is a serious problem for researchers who try to simulate the development of life satisfaction under changing climatic conditions. In this regard, Frijters and Van Praag (1998: 75) note: “The problem becomes greatest when it comes to computing the effect of climate change upon well-being... Well-being is generated by the interaction of highly correlated [climate] variables, whose cause-and-result structure is unknown.”

decreases well-being? And how long is it supposed to rain until affects and life satisfaction ratings are curbed to a measurable degree? In contrast to these obscurities, the impact of sunlight is thoroughly researched. As already discussed, short periods of sunshine are already sufficient to boost a person's level of serotonin and, in turn, his or her affective well-being. Therefore, the following empirical analyzes focus on the impact of sunshine on life satisfaction. To be sure that our definition of a 'sunny day' does not include days with mixed weather, i.e. with alternating sunny and rainy periods, we define a sunny day as a day with a relatively long duration of sunshine *and* with no rain. All other days which are characterized by ambiguous, rainy or cloudy weather are used as the point of reference in the models. Hence, the central hypothesis which guides our empirical research reads as follows: *Respondents whose interview took place on an unambiguously sunny day report a higher life satisfaction compared to all other respondents, ceteris paribus.*

3 Data and Measures

3.1 Data

To date, the influence of situational factors (like weather) on life satisfaction was mostly investigated in experimental research with very small and homogenous samples. In contrast to these studies, we wanted to base our empirical analysis on respondents who were interviewed for representative, large-scale surveys. However, testing our hypothesis with survey data is tied to some preconditions and only a few surveys meet these requirements: We decided to use three data sets: (a) the *Eurobarometer 67.1*, which was collected in 2007 (EB 2007) (b) the *Eurobarometer 69.2* from 2008 (EB 2008) and (c) the *German General Social Survey* from the year 2008 (GGSS). All three data sets meet several basic conditions: First, respondents answered at least one question on their life satisfaction. Secondly, the day of the interview is documented in these three studies. Third, the place of the interview can be reconstructed for at least parts of the sample. Information about the day and place of the interview is necessary in order to be able to add the information on the local weather on the day of the interview to the data set. However, the city of residence can only be identified for a smaller part of the respective sample. More precisely, we were able to identify all respondents who live in some major German cities.⁹ Respondents from these cities can only be used for the analyzes if a fourth condition is fulfilled: that the *Deutsche Wetterdienst* (DWD), the German Meteorological Service, maintains a weather station in the respective city. For every respondent from one of these cities, the local sunshine duration and precipitation levels on the day of the interview were added to the survey data. For the sake of comparability, we finally tried to harmonize the survey periods. In Study 3 (based on the GGSS), we therefore use only a part of the data which was collected in springtime 2008. Table 1 provides a general overview on the respective time periods and on the regional distribution of the three samples.

⁹ For every respondent, the Eurobarometer (EB) includes information on the federal state (*Bundesland*) and the GGSS on the administrative district (*Regierungsbezirk*). To identify the city of residence, we had to combine this data with other information on the population size of the respondent's residence. Considering both elements in combination allowed us to identify a couple of major German cities. For example, the federal state of Hesse has only one city with more than 500,000 inhabitants: Frankfurt on the Main. Other major cities, like Berlin, Hamburg or Munich, can be identified in a similar way. As the administrative district is a more specific type of information compared to the federal state, Study 3 (based on the GGSS) includes nine German cities whereas Study 1 and 2 (based on the EB) includes only five cities.

Table 1 Periods of data collection and regional distribution of the three samples

City	Weather station	Study 1	Study 2	Study 3
		EB 2007 14/2/2007–7/3/2007	EB 2008 31/3/2008–23/4/2008	GGSS 1/3/2008–30/4/2008
Berlin	Berlin-Tempelhof	73	76	37
Frankfurt M.	Frankfurt-Airport	32	36	12
Hamburg	Hamburg-Fuhlsbüttel	31	28	25
Stuttgart	Stuttgart-Echterdingen	49	35	13
Hanover	Hanover-Langenhagen	14	16	–
Bremen	Bremen	–	–	8
Dresden	Dresden-Klotzsche	–	–	21
Leipzig	Leipzig-Schkeuditz	–	–	17
Magdeburg	Magdeburg	–	–	19
Munich	Munich-Airport	–	–	27
N		199	191	179

3.2 Measures

(1) *Life Satisfaction*. The three studies measured life satisfaction with different questions. (a) In EB 2007 (Study 1), respondents had to evaluate their satisfaction with two important areas of life, their private and professional life. They were asked: “To what extent would you say that the life you live allows you to feel fulfilled in your private life/in your professional life”. Possible responses ranged from “totally fulfilled”, “fairly fulfilled”, “not very fulfilled” to “not at all fulfilled”.¹⁰ (b) In EB 2008 (Study 2), the question was: “On the whole, how satisfied or not are you with the life you lead”. Four answers were available: “very satisfied”, “fairly satisfied”, “not very satisfied” and “not at all satisfied”. (c) The GGSS (Study 3) contained a third question: “If you were to consider your life in general these days, how happy or unhappy would you say you are, on the whole”. Once more, respondents had to choose among four answers: “very happy”, “fairly happy”, “not very happy” and “not at all happy”.¹¹

(2) *Sunny Weather*. Days with unambiguously nice weather were identified by using two common weather indicators: the total sunshine duration in hours and the total precipitation in millimeters per square meter. Both indicators are collected daily by the DWD for several dozen German weather stations. Based on these indicators, we constructed a dummy variable which identifies all sunny days in the survey period in the respective city. Thereby one has to keep in mind that the surveys at hand were conducted in February, March and April. These months are characterized by alternating weather conditions and generally comprise cold and cloudy days, warm and sunny days, as well as days with mixed weather. Furthermore, one has to consider that in these months only about 10 hours lie between sunrise and sunset, so that hours of sunshine have a natural and rather narrow limit. For these reasons, we decided to code all days as sunny days on which the sunshine duration

¹⁰ Only respondents of employable age answered the question that measures fulfillment with professional life.

¹¹ Possible differences between the questions and the underlying constructs are discussed more precisely in the final section of this paper.

Table 2 Average weather conditions during the survey periods and the proportion of respondents interviewed on a sunny day

	Study 1 (EB 67.1)	Study 2 (EB 69.2)	Study 3 (GGSS)
Sunshine (mean, h/day)	2.1	3.0	4.3
Precipitation (mean, mm/m ²)	2.6	2.5	2.1
N, interviews on sunny days	26	28	42
%, interviews on sunny days	13	15	24

exceeded four hours and simultaneously no precipitation was measured.¹² All other days are characterized by mixed or rather bad weather. Respondents surveyed on these days serve as the reference point in the regression models. Table 2 provides an overview of the proportion of respondents interviewed on sunny days.

(3) *Control variables.* Our research interest is to identify the influence of sunny weather on people's life satisfaction judgments. To estimate this sunshine effect without major biases, we have to control for some other variables which may be associated with weather conditions, as well as with life satisfaction. First of all, the city of residence of the respondent has to be controlled. Cities can be associated with typical weather conditions due to their geographical location. Additionally, they may also offer a different level of quality of life and can therefore affect the average life satisfaction of its inhabitants. If, for example, Stuttgart offers a higher quality of life than Hanover and also has more sunshine than Hanover, then the sunshine effect on life satisfaction would be overestimated due to this coincidence. To eliminate such biases, dummy variables for each of the cities are included in the regression models.

Additionally, we control for variables which are widely used for the explanation of individual differences in life satisfaction. The studies at hand provide measures for age, sex, education, unemployment, marital status and immigrant background. To the extent that it is possible, we include additional (proxy-) variables that capture the financial situation of the respondent (net income, possessions of consumer goods, possession of real property). Detailed information about these measures can be found in the Appendix (Table 4). It is highly unlikely that one of these control variables is systematically correlated to the weather. However, it still seems possible that certain social groups are accidentally disproportionally often surveyed on sunny days. We therefore include these variables in the models. However, we abstain from discussing the theoretical links of each and every one of these variables to life satisfaction.¹³

¹² A more restrictive definition of a sunny day would have resulted in a very small number of respondents interviewed on sunny days.

¹³ In addition to the weather, other situational factors can impact general life satisfaction as well. As Schwarz et al. showed, such mundane events like finding an apparently overlooked coin at the copying machine can positively influence a person's life satisfaction. Furthermore, it is possible that other situational factors moderate the impact of weather on life satisfaction. For instance, the mood-improving effect of sunny weather could be reinforced by another mood-improving event like a meeting with a good friend or could be diminished or distorted by negative events like losing your wallet. Unfortunately, we can not control for all these mood-inducing events because there is no information about these events in our data. However, this should not be a problem for our research because of the fortuitous occurrence of such mood-inducing events. Instead, it could be assumed that the influence of these situational factors is balanced out unless they are produced systematically by the research design itself or by the interview situation. Therefore, additional controls of other situational factors would be helpful (particularly to compare the various effects), but are in no way necessary.

4 Findings

We test the influence of unambiguously sunny days on the self-reported life satisfaction by using multivariate OLS regression models. These models include the weather variable, the above-mentioned control variables, as well as dummy variables for the respondents' cities of residence. As our dependent variables, strictly speaking, are only measured on an ordinal scale, we have calculated additional ordinal and logistic regressions for all models. As these additional models show similar effects, we decided to present only the linear models at this point. For one thing, linear regressions are easier to interpret. For another, in comparison to logistic regressions, their results are quite robust, even when using small sample sizes.

(1) *Study 1.* Our first analysis is based on data from the Eurobarometer 67.1, which were collected in February and March 2007. We estimate to what degree sunny weather on the day of the interview affects the respondents' self-reported *fulfillment with private life and professional life*. The regression models show a surprisingly strong sunshine effect on both measures (Table 3): Respondents interviewed on a very sunny day reported significantly more satisfaction with their private and professional life compared to respondents whose interview took place on any other day ($P < 0.01$). The difference is striking: Regarding a person's satisfaction with private life, sunshine can lead to an average increase of 0.30 points on the fulfillment scale (ranging from 1 to 4). The sunshine effect on fulfillment with professional life is still stronger: Sunny weather can boost a person's job satisfaction, *ceteris paribus*, by 0.56 points. Only two of the explanatory variables have a stronger impact on a person's fulfillment with private and professional life: First, respondents in a

Table 3 Weather effects on self-reported life satisfaction in three German samples

Variables	Study 1 (EB 67.1)		Study 2 (EB 69.2)	Study 3 (GGSS)
	Fulfillment in private life	Fulfillment in prof. life	General life satisfaction	General happiness
Age	-0.003	-0.001	0.005⁺	-0.005⁺
Sex (male)	-0.20*	0.01	-0.24*	-0.08
Education (years)	0.01	-0.01	0.01***	-
Education (degree)	-	-	-	0.07
In a relationship	0.63***	0.60***	0.22*	0.27**
Unemployment	-0.71***	-1.19***	-0.42*	-0.04
Income group	-	-	-	0.04
Consumer goods	-0.02	0.03	0.09*	-
Real property	-0.03	0.03	0.10	-
Immigrant	-0.16	0.33	0.01	-0.07
Sunny day ^a	0.30**	0.56**	0.10	0.19⁺
R ²	0.41	0.45	0.28	0.27
N	185	134	191	172

Linear regression models. Unstandardized regression coefficients (b). The dependent variables range from 1 (lowest satisfaction) to 4 (highest satisfaction). +/*/**/*** Coefficient is significant at $P < 0.10/0.05/0.01/0.001$ (robust standard errors)

^a Since we formulated a directional hypothesis for sunny weather, we use a one-tailed test of significance. All models additionally control for the city of residence of the respondent. For the sake of clarity, however, we do not document these coefficients

relationship report a significantly higher satisfaction on both domains compared to respondents without a close partner. Secondly, unemployed respondents are less satisfied with their private lives and, as one would have expected, much less satisfied with their professional life. Overall, these results strongly support our initial hypothesis: Satisfaction ratings do indeed increase on sunny days.

(2) *Study 2.* The second regression analysis uses the Eurobarometer 69.3. This survey was conducted to a great extent in April 2008. In contrast to Study 1, the response variable now measures *general life satisfaction* with one of the standard questions. Again, we estimate the influence of sunny weather on the day of the interview on life satisfaction. As can be identified in the regression model (Table 3), people are marginally more satisfied during sunny periods. On a sunny day, the average level of satisfaction rises about 0.1 points compared to any other day. Although the effect points into the expected direction, it remains insignificant. In our second sample, the weather thus only has a very weak impact on general life satisfaction that does not differ significantly from zero. Some other explanatory variables, however, can lead to significant changes in a person's life satisfaction: Especially those in relationships and better-educated respondents assess their lives more positively, while unemployed people, as well as males, report to be less satisfied with their lives in general.

(3) *Study 3.* For a third analysis, we use data collected in March and April 2008 for the GGSS. In this survey, *general happiness* was measured with one question: "If you were to consider your life in general these days, how happy or unhappy would you say you are, on the whole". The regression model which estimates the influence of sunny weather on these self-reports is specified similarly as the models in Study 1 and 2. However, the measurement of the control variables slightly differed from the aforementioned studies, because the GGSS did not contain exactly the same variables. As an example, in GGSS, the respondent's financial situation can be measured directly by using data on his or her net income. Looking at the results of the regression model, sunny weather is again positively associated with life satisfaction (Table 3). The respective model shows that respondents whose interview took place on a sunny day reported a higher life satisfaction—by 0.19 points—compared to respondents who were surveyed on other days. The sunshine effect is significant ($P < 0.10$). In addition to living in a close relationship, sunshine is the only significant influence on general happiness in the model. We regard this finding as another piece of evidence for the correctness of our initial assumption.

(4) *Summary of the regression models.* In two out of three samples (Study 1, Study 3), our analyses support the assumption that sunny weather induces a significant and positive change in people's evaluations of their lives. In one sample (Study 2), however, sunshine was only weakly and insignificantly associated with life satisfaction. The size of the sunshine effect varies considerably between the four different models: If we relate the effect sizes to the range of the underlying satisfaction scales, sunshine may lead to an increase in self-reported fulfillment with private and professional life of more than 10% (Study 1). Further on, sunshine can improve a person's general life satisfaction. The analyses show that people's average satisfaction levels are 3% (Study 2) to 6% (Study 3) higher on unambiguously sunny days compared to all other days.

5 Discussion

We investigated the impact of weather conditions on a person's self-reported life satisfaction. Weather was assumed to be one situational factor which could influence a person's

judgment about his or her life. In particular, we expected that people would report a more positive life satisfaction on days with unambiguously ‘nice’ weather. Theoretically, we reasoned that sunshine can activate positive emotions and moods in many people due to a sunlight-induced increase of serotonin in the human brain. Moreover, we have argued that a positive affective state can, in turn, positively influence a person’s evaluation of his or her life. People in a good or bad mood perceive their lives differently, are aware of different aspects of their lives, and tend to use their feelings as information. Based on these theoretical considerations, we hypothesized that persons would report a higher life satisfaction on sunny days. This assumption was then tested in three German samples. All in all, the results are mostly consistent with the initial hypothesis. In all three samples, we found that respondents surveyed on days with exceptionally sunny weather reported a higher life satisfaction compared to respondents interviewed on days with ordinary weather. In two out of three samples, this difference was statistically significant. Hence, the supposed sunshine effect on peoples’ life satisfaction does indeed exist.

However, the size of this sunshine effect varied among the three studies. In Study 1, sunny weather on the day of the interview was associated with a considerable increase in satisfaction judgment. If brought into relation to the range of the underlying satisfaction scale, respondents’ assessments of their private life increased about 10%. Regarding professional life, we even found a rise of 18%. In Study 2 and Study 3, in contrast, sunshine lead only to a moderate increase in people’s general life satisfaction of 3 and 6%, respectively. How can we explain the inconsistent size of these effects? We suppose these differences may result from the questions that were applied to measure life satisfaction. These questions are not identical among the studies and thus, it is a matter of debate whether or not the same underlying construct is measured. In Study 2 and Study 3, where only a rather small sunshine effect was identified, life satisfaction was measured with some of the conventional, well-established questions (“On the whole, how satisfied or not are you with the life you lead”; “If you were to consider your life in general these days, how happy or unhappy would you say you are, on the whole”). Both are frequently and long-used in life satisfaction research (The Economist 2005; Veenhoven 2008). In Study 1, sunshine effects were markedly stronger. However, another question was used in this study (“To what extent would you say that the life you live allows you to feel fulfilled in your private life/in your professional life”) that differs from the before-mentioned in two aspects: First, it is not aimed to assess the *whole* life in general, but instead distinguishes between private and professional life. Secondly, one can speculate that due to its wording, this question did not solely measure cognitive well-being, but affective well-being as well. Especially the word *feel* could provoke respondents to consult their feelings and moods before answering this question.¹⁴ If so, it seems perspicuous that sunshine effects are larger in Study 1. According to our theoretical argumentation, the sunshine effect on life satisfaction is mediated by the affective state of the person. Thus, sunshine should have a larger impact on the affective well-being and only weaker influence on (cognitive) life satisfaction of a person. At this point, however, we are not able to test this assumption in detail.

Assuming that the assessment of life satisfaction follows patterns similar to any other judgment process, it seems appropriate to compare the weather-induced effects found in this study with weather effects that were demonstrated in other studies which did not focus on life satisfaction. In particular, two recently published studies investigated to what extent weather conditions influence the assessment of political issues. In a first contribution,

¹⁴ Cautiously speaking, studies which use this particular question for measuring subjective well-being are not very numerous. Aside from the EB 67.1 wave that we analyzed here, we do not know any other study.

Cohen (2011) shows that the popularity of former US-president George W. Bush is positively associated with sunshine: If more sunlight was recorded on the day of the interview, more people were in favor of the president. This effect was rather large in spring and more pronounced among people without a close partisan attachment to either the republican or democratic side. Secondly, Mutz and Kämpfer (2011) demonstrated that individuals who were surveyed on particularly sunny days report an above-average satisfaction with the state of democracy in the country and with the work of government. Furthermore, people estimated the economic climate one year onward more positively on a sunny day. Persons who were questioned on rainy days assessed all three issues more negatively. In comparison to the study at hand, the impact of weather conditions on people's assessments of political and economic issues (as reported by Mutz and Kämpfer) was rather strong. People's life satisfaction, after all, seems to depend less on the weather than their satisfaction with the political situation, at least if life satisfaction is measured by one of the commonly used questions. Taking this into account, our findings may raise only some minor doubts in regard to the validity and reliability of self-reports of life satisfaction as an indicator for a person's 'real' quality of life. Self-reports of life satisfaction can, in fact, be biased by some (major) shifts in weather conditions. In comparison to other studies, however, this bias is not too strong.

Some clues even signify that life satisfaction might be less prone than other judgments to be influenced by situational factors. One can generally assume that the impact of situational conditions—like the weather—on judgment is larger if the respondent cannot rely on any prior assessments of the same issue at the time of the interview. In other words: Weather should only affect the judgment of 'viewless' respondents who did not already form a clear opinion about a certain issue. It's likely that many people do not regularly reflect on political issues and therefore do not have a consolidated political opinion (Cohen 2011). However, one may assume that a large majority of people do, at least once in a while, reflect on their satisfaction with life in general and with different areas of life in particular, i.e., people have already made up their minds and can rely on these prior judgments when they are interviewed. Schimmack et al. argue in a similar way: "participants spend a lot of time thinking about their lives. As a consequence, they have a pre-stored evaluation of their life and pre-stored theories about the determinants of their life that differ among individuals. At the time of the life satisfaction judgment, participants may report a pre-stored evaluation" (2002a: 374). It will be a task for future research to investigate to what degree the impact of situational factors on judgments varies with the degree to which a prior forming of opinions on a certain issue has already taken place.

Finally, we would like to point out two weaknesses of our study that have to be kept in mind. First, our empirical analyses were based only on respondents from major cities. As anonymity is assured in all of the three surveys we used, we could only identify the place of the interview for those participants who lived in a few big cities. Because weather conditions can change significantly between different cities and regions in a given territory, the linkage of weather data with survey data is only sound if done on a local level. This specificity and accurateness, however, comes at a price, in terms of a small sample. Additionally, the findings should not prematurely be generalized for the whole German population. We do not know yet if the demonstrated sunshine effect would, for example, appear in a sample of people from rural areas in a similar way. A second point of critique might point to the survey periods: We solely analyzed data that were collected in early spring, thus in a period in which the weather in Germany changes rapidly from the generally cold winter season towards warmer and brighter days. It seems plausible that people respond particularly strong to these seasonal changes: After cold and dark winter

months, the first sunny days in spring could have a much greater impact on a person's serotonin levels and therefore could change a person's affective state significantly to the better, which, in turn, could result in more positive self-reports on life satisfaction. But in the event a person's serotonin is already on a high level, which can be presumed at least for the warm and sunny months in summer, additional exposure to sunlight is not likely to improve affective well-being any further. Hence, in summer one may not expect to find the same association between sunshine and life satisfaction as a person's need for sunlight might already be saturated.¹⁵ If these assumptions are correct, we have analyzed a period of the year where one can expect relatively strong impacts of weather on affective well-being and life satisfaction. Thus, we do not know yet whether the sunshine effect demonstrated in this study is robust over all seasons or just a specific feature of springtime.

Appendix

Table 4 Description of variables

Variable	Range	Description
Life satisfaction (EB 67.1)	1–4	“To what extent would you say that the life you live allows you to feel fulfilled in your private life/in your professional life”. (1) “not at all fulfilled”, (2) “not very fulfilled”, (3) “fairly fulfilled”, (4) “totally fulfilled”.
Life satisfaction (EB 69.2)	1–4	“On the whole, how satisfied or not are you with the life you lead”. (1) “not at all satisfied”, (2) “not very satisfied”, (3) “fairly satisfied”, (4) “very satisfied”.
Life satisfaction (GGSS)	1–4	“If you were to consider your life in general these days, how happy or unhappy would you say you are, on the whole”. (1) “not at all happy”, (2) “not very happy”, (3) “fairly happy”, (4) “very happy”.
Age (all studies)	15–95	Age of respondent, original values
Sex (all studies)	1, 0	Sex of respondent: (1) male, (0) female.
Education, years (EB 67.1, 69.2)	13–35	Age when respondent finished full-time education, original values
Education, degree (GGSS)	1–3	Highest level of education: (1) incomplete education, secondary education at the lower level; (2) completed secondary education at the intermediate level; (3) completed secondary education at the maturity level.

¹⁵ Another explanation for a supposedly weaker or even negative effect of sunshine in summer months is given by Cohen (2011). He speculates that „the positive effects of sunlight on mood should be naturally minimal during the summer, because the length of summer days naturally offsets melatonin production, which dramatically reduces the positive effects of sunlight.” Furthermore, Cohen reasons that sunlight during the summer may have a negative effect on mood due to the hot temperatures that accompanies sunshine in summer. Very hot temperatures should reduce the affective well-being of a person. Some studies even demonstrated that irritability (Holland et al. 1985), aggression (Berkowitz 1993) and even suicides are a side-effect of hot temperatures (Barker et al. 1994; Page et al. 2007).

Table 4 continued

Variable	Range	Description
In a relationship (all studies)	1, 0	Marital status of respondent: (1) living together with spouse or close partner, (0) other status.
Unemployment (all studies)	1, 0	Current employment status of respondent: (1) unemployed, (0) other status.
Income group (GGSS)	0–7	Monthly net income of respondent: (0) no income, (1) under 500 €, (2) 500–999 €, (3) 1,000–1,499 €, (4) 1,500–1,999 €, (5) 2,000–2,499 €, (6) 2,500–2,999 €, (7) 3,000 € and more.
Consumer goods (EB 67.1, 69.2)	0–6	Six-Item Index: Ownership of television, DVD player, CD player, computer, car, internet access.
Real property (EB 67.1, 69.2)	1, 0	Ownership of fully paid apartment or house: (1) yes, (0) no.
Immigrant (all studies)	1, 0	Country of birth of respondent: (1) not born in Germany, (0) born in Germany.
Sunny day (all studies)	1, 0	Unambiguously nice weather at the day of the interview: (1) sunshine duration above 4 h with no precipitation, (0) other weather conditions.

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