

Supporting Information

Headey et al. 10.1073/pnas.1008612107

SI Materials and Methods

This file contains information about (i) The German Socio-Economic Panel (SOEP), (ii) the main measures, and (iii) regression diagnostics checking whether assumptions required for panel regression analysis are met.

Data: German Socio-Economic Panel (SOEP), 1984–2008. SOEP began in 1984 in West Germany with a sample of 12,541 respondents in \approx 5,000 households (1). Interviews are conducted annually with everyone in sample households aged 16 and over. For this paper it is particularly valuable to be able to link data on spouses. The cross-sectional representativeness of the panel is maintained by interviewing “split-offs” and their new families. For example, when a young person leaves home (splits off) to marry and set up a new family, the entire new family becomes part of the panel. The sample was extended to East Germany in 1990. Since then it has been boosted by the addition of new immigrant samples, a special sample of high-income individuals, and recruitment of new respondents partly to increase numbers in policy groups. There are now over 60,000 respondents on file, including some grandchildren as well as children of the original respondents. Respondents have participated between 1 and 25 times; the average to date is 8.

For this paper, the sample is restricted to prime-age adults, defined as those aged 25–64. The aim is to restrict analysis to mature-age individuals who, according to set-point theory, should have stable levels of life satisfaction. The lower age limit excludes individuals whose personalities may still be changing. The top limit excludes senior citizens who might find it odd to talk about life goals/priorities, especially career goals, in the later part of their life when most are retired.

Sample numbers reported in the tables below range from a low of 853 in Table S1 to a high of 142,390 in Table 1. In the former table, analysis is restricted to those aged 25–64 participating in all 25 waves of SOEP to date. The total of 142,390 in column 1 of Table 1 comprises each observation year for all individuals aged 25–64, who have valid values for the variables in the equation and who participated in SOEP for at least 2 y in 1984–2008 (2 y of observation being the minimum required for a fixed-effects panel regression analysis; see below).

Data analysis set-up for analysis of medium-term change in life satisfaction. Almost all longitudinal analyses of individual or household panel data are based on annual waves, reflecting the time interval at which data are actually collected. But it is already known that annual changes in life satisfaction are mainly just temporary fluctuations due to life events. In this paper, our aim is to account for medium- and long-term stability and change, so it was appropriate to calculate 5-y averages of life satisfaction scores for the 25 y of data (1984–1988, 1989–1993, etc.) and to assign these averages to each year within its 5-y period. This setup allows us to relate respondents’ annual scores for each explanatory variable to measures of medium-term change in life satisfaction. **Panel attrition and potential response bias.** There are several potential problems of bias in panel surveys. One near-certainty is different rates of attrition (dropout) among different demographic subsets of the panel. This is partly corrected in a routine way by using longitudinal weights to adjust for differences between panel respondents’ characteristics and updated census characteristics of the national population. But this does not necessarily guard against differential attrition in terms of variables crucial to a particular piece of research. Could it be that there is differential dropout by levels of life satisfaction? This seems unlikely:

the pattern of cumulative but not constant change in life satisfaction recorded in Table S1 could only be a biased overestimate if individuals with stable satisfaction scores tended to drop out of the sample at a higher rate than those recording large gains or losses. Survey methodologists know that the opposite is generally true; the hardest people to retain in a survey are those whose lives are in turmoil. It is also the case that investigations into attrition in the SOEP panel have not discovered differences based on life satisfaction (2).

A second possible source of bias might be panel conditioning effects. That is, panel members might tend to change their answers over time—and answer differently from the way non-panel members would answer—as a consequence of being panel members. There is some evidence in SOEP that panel members, in their first few years of responding, tend to report higher life satisfaction scores than when they have been in the panel for a good many years (2). This could be due to social desirability bias—a desire to look good and appear to be a happy person, which is stronger in the first few years of responding than in later years. Or it could be due to a learning effect—learning to use the middle points of the 0–10 scale, rather than the extremes, and particularly the top end.

To compensate for these possible sources of bias, we include in all equations a variable that measures the number of years in which each panel member has already responded to survey questions.

Measures. Life satisfaction. The dependent (outcome) variable in all equations is life satisfaction, measured in SOEP on a 0–10 scale (“totally dissatisfied” to “totally satisfied”). The terms *life satisfaction*, *happiness*, and *subjective well-being* (SWB) tend to be used almost interchangeably in the psychology and economics literatures, although operationalizations differ (3). Single-item measures are plainly not as reliable or valid as multi-item measures of SWB, but are widely used in international surveys and have been reviewed as acceptably valid (3). In regression analyses in this paper, as in almost all recent papers on life satisfaction, what is really an ordinal scale is treated as interval level. Detailed checks by many investigators have shown that results using ordinal and interval scale assumptions are substantively the same (2, 4). Our own tests of linearity, using kernel density estimates and plots, confirmed earlier results (Fig. S1).

In this paper, a very straightforward approach is used for measuring stability and change in life satisfaction, 1984–2008. Table S1 and Fig. 1 show percentages of respondents recording upward or downward changes of 25 percentiles, 33.3 percentiles, or 50 percentiles in the life satisfaction distribution between 1984 and 1988 (baseline) and 2004 and 2008 (latest period available). Some previous researchers, viewing themselves as assessing the stability of life satisfaction rather than necessarily testing set-point theory, have followed a similar approach in also using multiyear averages (5), whereas others have used more complicated approaches, based on using regression estimates or structural equation modeling (6, 7). All approaches have yielded similar results.

Personality traits. In 2005, SOEP included measures of personality traits for the only time (to date). The instrument used was a short version of the Big Five Personality Domains, the NEO-AC (8). The traits in the Big Five are neuroticism, extroversion, openness, agreeableness, and conscientiousness. SOEP used short versions of the five scales reported to be satisfactorily correlated with the much longer versions developed by psychologists (9).

Psychologists usually take the view that personality is about 40–50% hereditary and quite stable, at least from the age of about 25–30 onward (10). By including personality traits measured in 2005 on the right-hand side of equations to account for life satisfaction in earlier as well as later years, we are in effect assuming that personality is completely stable. If it were completely stable, then of course it would not matter when it was measured. However, the assumption may not be entirely correct. There is some debated evidence that ratings on personality traits might be changed to a moderate degree by life experiences, such as having a stable marriage or an absorbing job (11, 12).

Life goals/priorities. The data contain a lot of information about what economists term preferences, choices, and constraints. Preferences, here given a broader meaning than is usual in economics (hence not restricted to material consumption), are first indicated by questions about the importance of particular life goals. It has proved difficult to design reliable survey measures of life goals/priorities, but the SOEP research team has developed items that have a stable factor structure and adequate test/retest reliability (1, 13, 14). Goals have been measured on five occasions (rather than annually) in SOEP, starting in 1990. The instrument set out to measure the importance of three sets of goals:

- (i) Success: material goals and career success
- (ii) Family life: marriage, children, and the home
- (iii) Altruism/prosocial: friendship, helping and meeting others, social and political activism

Respondents answered questions on a 1–4 scale running scale running from “not at all important” to “very important.” The success goals comprised two equally weighted items: “being able to buy things” and “success in one’s job.” The family goals index consisted of items measuring the importance of a good marriage and having children. Finally, the altruistic goals index gave equal weights to “being involved in social and political activities” and “helping other people or meeting them for social events.” The index correlates modestly ($r = 0.09$, $P < 0.001$) with a measure of the frequency with which volunteer work is actually undertaken.

Because life goals have only been measured five times in the SOEP survey, it was necessary to impute values for the missing years. Otherwise, thousands of observations would have been lost from the analysis. Imputation was done in a straightforward way. Averages (means) were calculated for each individual for the years 1990 and 1992 combined, then 1992 and 1995, 1995 and 2004, and finally, 2004 and 2008. Individual mean values were then assigned for the years between these pairs of dates (the mean of 1990 and 1992 was assigned for 1991, etc.). For the years before 1990, we assigned 1990 values.

As noted in the main text, previous research has shown that what matters to life satisfaction is not transient commitment to particular life goals, but persistent long-term commitment (14, 15). We measured long-term commitments by taking average (mean) scores on the goals indices for the full period of the SOEP survey.

Religion. Questions about the frequency with which participants attend church and engage in other religious activities have been asked regularly, but not every year, since 1990. (An additional question about “the importance of religion in your life” has been asked only intermittently, so the data are unsuitable for panel analysis.) As well as being positively related to life satisfaction, church attendance is correlated with giving priority to both altruistic goals ($r = 0.09$, $P < 0.001$) and family goals ($r = 0.11$, $P < 0.001$). It is also positively related to reported time spent on volunteer activities ($r = 0.22$, $P < 0.001$). There is a negative correlation with priority for success goals ($r = -0.14$, $P < 0.001$).

Preferred and actual working hours. The tradeoff between paid work (or rather the consumption that work pays for) and leisure is central to welfare economics. Respondents in the SOEP panel are asked both how many hours per week they actually work (in all

jobs combined, if they have more than one job) and how many they would prefer to work. The gap between these two figures can be treated as a rough measure of the degree to which they are achieving their preferred tradeoff/choice between work and leisure, subject to the constraints of their current labor market opportunities. Here we classify individuals whose actual working time is within 3 h of their preferred time as having their preferences met. We treat those who work over 3 h more than they want as overworked, and those who work over 3 h less than they want as underworked. Other hours gaps were tested, but the 3-h gap variables showed the highest correlation with life satisfaction. Additionally, we include the (involuntarily) unemployed, who can be assumed to regard themselves as underworked. A final group comprises those not currently in the labor force, including students, homemakers, and retired people.

Social participation. The social participation index used in this paper consists of two highly correlated items about frequency of “meeting with friends, relatives, or neighbors” and “helping out friends, relatives, or neighbors.” The questionnaire scale for these items offers three options: every week, every month, and seldom or never.

Healthy lifestyle. The only healthy lifestyle measure available from the inception of SOEP relates to frequency of participation in active sport or exercise. This is asked on a four-point scale running from “almost never or never” to “at least once a week.” An additional SOEP measure reflecting a healthy or unhealthy lifestyle (unfortunately only available for a few recent years) is body mass index (BMI). BMI is intended to measure whether a person has an appropriate weight relative to his/her height. SOEP has included self-report measures of weight and height every 2 y since 2002. It has been found that self-report measures are reasonably valid, although overweight and obese people have a slight tendency to underestimate (16).

BMI is defined as weight (kilograms) divided by height (meters) squared. A BMI under 18.5 is considered underweight, 18.5–24.9 is considered normal weight, 25–29.9 is considered overweight, and a BMI of 30 or more is considered obese.

Variables included primarily as controls. Three sets of variables have been included in all statistical analyses, mainly as controls.

1. Standard demographic variables. Several demographic variables are known to be correlated with life satisfaction, but are not usually thought of as a matter of individual choice. The list of controls included here include gender, age, marital/partnership status, health disability status (a rating of over 50% disabled), unemployment status, and being foreign born. It is known that life satisfaction declines in middle age and rises again around retirement age. To capture these changes age, age-squared and age-cubed terms were included in equations; all were statistically significant. A special demographic variable, which is usual to include for Germany, distinguishes between East and West Germans. Our findings confirm the lower life satisfaction levels of East Germans. Educational attainment and occupational status were not included in equations because it is reasonable to regard them as endogenous, being partly a matter of choice and also likely to be linked to success goals. In any case, both variables are only very weakly related to life satisfaction, so their inclusion would have made virtually no difference to results.

2. Adverse life events that may temporarily reduce life satisfaction. It is well known that adverse life events have moderate and mostly temporary negative effects on life satisfaction (6). It was important to control for these temporary effects in analyzing the causes of medium-term change. The potentially adverse events included in our analyses were marital separation and divorce, becoming disabled, job loss, going out of business, and becoming income poor. The European Union’s definition of relative income poverty is used—a household-size-adjusted disposable income below 60% of the national median. Some of the events that have been included, particularly losing a job or a business, be-

coming poor, and becoming disabled, may be regarded as involuntary economic constraints on the range of life choices otherwise available. We also included in equations two potentially positive events: getting married and the birth of one's first child. (The birth of second and subsequent children generally has no effect on parental life satisfaction.)

3. Macroeconomic conditions that may affect life satisfaction. Finally, life satisfaction can be affected by macroeconomic conditions. In assessing medium-term changes in individual life satisfaction, we also need to net out these macro effects. Two measures of the business cycle are the national unemployment level and changes in GDP, or GDP per capita. Because the measures are highly correlated, it was inappropriate to include more than one in our statistical models; we selected the unemployment level that had the strongest (negative) relationship with life satisfaction.

Regression analyses and regression diagnostics. In the regression analyses in this paper, personality traits (self and partner) are viewed as causally antecedent to choice variables, so their effects are netted out (controlled) in estimating the impact of choices. The effects of control variables are also netted out in all equations.

The main type of regression analysis used here is GLS random-effects panel regression analysis. The random-effects analyses take account of both cross-sectional between-person differences and of over-time (longitudinal) within-person changes. In Table S2, the variables of main interest are self and partner personality traits, and in Table S3 life goals/priorities are the main focus. In these tables the analysis deals with relationships between static explanatory (independent) variables and a changing outcome (dependent) variable, namely the 5-y life satisfaction measure.

The GLS model of SWB is conventionally formulated as in Eq. 1 in which i refers to the individual and t to the year:

$$SWB_{it} = \alpha_0 + \beta_1 C_{it} + \delta_1 Tr_{it}^s + \delta_2 Tr_{it}^p + \delta_3 Lg_{it} + \delta_4 Ch_{it} + \mu_i + \varepsilon_{it}, \quad [S1]$$

where C_{it} are the control variables, including life events; Tr_{it}^s are the individual's own personality traits and Tr_{it}^p are partner's personality traits; Lg_{it} are the various life goals; Ch_{it} are the behavioral choices (work-leisure, exercise, and social participation); μ_i is time invariant unobserved heterogeneity or individual effects; and ε_{it} are error terms. Within- and between-person error variance components, reported in the tables below, are given by σ_u and σ_e , and ρ represents the share of variance due to individual heterogeneity.

A limitation of random-effects analysis is that it is assumed that omitted time invariant factors, or unobserved heterogeneity as it is called (e.g., genetic factors other than personality traits, ability, and motivation) are not correlated with the outcome variable and the explanatory variables. In practice, standard Breusch-Pagan and Hausman tests of this assumption indicate that it was not met in this model. So our estimates relating to personality traits and life goals might be biased. Plainly, nothing practical can be done about this concern, unless we relax the assumptions that (i) adult personality is stable (which no psychologist would accept) and that (ii) what matters with life goals is to be committed and pursue them persistently. In regard to goals, it should be noted that a recent experimental study indicated that altruistic goals and behaviors are associated with greater life satisfaction (17). In this study, by virtue of the randomized design, omitted variables bias could not pose a problem.

In Table 1 and Table S4, results are given for the effects on life satisfaction of preferred choice of working hours, social participation, and healthy lifestyle. Because these variables have all been measured annually in SOEP, it is possible to conduct both a random-effects analysis (Table S4) and a more pure within-person analysis of change, using a panel regression fixed-effects model (Table 1). In the latter model, the effects of time-

invariant factors are netted out, largely removing the risk of biased estimates.

Regression diagnostics. Standard diagnostic tests were run on the results given in Tables S2–S4 and Table 1 to investigate possible breaches of regression analysis assumptions. First, linearity: partial regression plots confirmed that the relationship between life satisfaction and each of the explanatory variables (except age) was approximately linear. Checks using Kernel density estimates and plots offered additional confirmation. An expected exception was the age variable; as previously noted, it is well established that life satisfaction declines a bit in middle age and then rises again around retirement age. This was covered by adding age-squared and age-cubed terms.

A second set of diagnostics, relating to normality of errors and homoscedasticity, found numerous minor violations of assumptions, as usually happens with large survey samples. For example, Hamilton's interquartile range test identified 0.12% of observations in Table S2 as severe outliers. We adopted the standard response of using robust (rather than classical) SEs for all analyses. Checks were also made to see if results were substantially changed when bootstrapping methods were used, because bootstrapping does not assume normal distributions. In fact, the results of main interest relating to self and partner personality traits, life goals, etc. scarcely changed. Effect sizes were barely affected, and the main results remained significant at the $P < 0.001$ level.

Tests to check for the possibility that our findings might be biased by a few extreme observations (outliers) were based on studentized residuals and also indicated some breaches of assumptions. However, as might be expected with a very large number of observations, leverage tests then indicated that observations with excessive residuals did not significantly affect coefficients or confidence intervals. In fact, even taking the potentially sample-biasing step of (temporarily), removing all cases with normalized residuals over +2.0 or under -2.0, had a barely visible effect on coefficients.

Multicollinearity. To assess whether multicollinearity was a problem for our main regression analyses, we examined variance inflation factors (VIFs). VIFs >10.0 are conventionally considered to be problematic. In this study, all VIFs were <2.0, except for the variables age, age squared, and age cubed.

Additional Discussion

We claim in Discussion that partner's neuroticism, altruistic and family life goals, church attendance, achieving one's preferred of choice of working hours, social participation, and exercise all have substantial effects on life satisfaction. This claim is made on the basis that they all have effects as large or larger than variables routinely described by researchers as having major effects on life satisfaction. Two such variables are the personality trait of extroversion and the status of being married. Partner's neuroticism has at least as large an effect on life satisfaction as extroversion, which is measured on the same 1–7 scale (for partnered individuals: partner's neuroticism, $\beta = -0.09$, $P < 0.001$; extroversion, $\beta = 0.05$, $P < 0.001$; the difference between the two coefficients falls just within a 95% confidence interval). Altruistic goals, family goals, church attendance, social participation, and exercise are all regarded as having substantial effects because standardized coefficients linking them to life satisfaction are as large or larger than the standardized coefficient for extroversion (extroversion, $\beta = 0.06$; altruistic goals, $\beta = 0.06$; family goals, $\beta = 0.07$; church attendance, $\beta = 0.10$; social participation, $\beta = 0.09$; exercise, $\beta = 0.07$). For both men and women, doing fewer paid hours of work than they want (coded as a dummy variable) appears to have nearly as big an effect on life satisfaction as not being married/partnered for both men (underworked, $\beta = -0.09$, $P < 0.001$; not married/partnered, $\beta = -0.13$, $P < 0.001$) and for women (underworked, $\beta = -0.09$, $P < 0.001$; not married/part-

Table S1. Percentage recording large changes in life satisfaction over progressively longer periods in 1984–2008: Individuals aged 25–64 ($n = 853$)^a

Change from 1984 to 1988 (baseline) to ...	Change of 25 percentiles or more, %	Change of 33.3 percentiles or more, %	Change of 50 percentiles or more, %
1984–1988 to 1989–1993	22.8	12.5	4.6
1984–1988 to 1994–1998	31.8	22.0	9.5
1984–1987 to 1999–2003	36.7	25.7	10.4
1984–1987 to 2004–2008	38.1	25.5	11.8

Source: SOEP 1984–2008. Sample comprises respondents aged 25–64 throughout the period. Results are longitudinally weighted.

Table S2. Effects of own personality and partner's personality on life satisfaction: GLS random-effects panel regressions (metric coefficients, P values based on robust SEs)

	All respondents own personality ^a	Partnered men: Own personality + partner personality ^a	Partnered women: Own personality + partner personality ^a
Neuroticism	−0.25***	−0.22***	−0.21***
Extroversion	0.07***	0.07***	0.04*
Openness	0.07***	0.07***	0.06***
Agreeableness	0.06***	0.06**	0.07***
Conscientiousness	0.07***	0.05*	0.02
Partner neuroticism		−0.10***	−0.08***
Partner extroversion		−0.01	0.01
Partner openness		0.04*	0.04*
Partner agreeableness		0.01	0.05*
Partner conscientiousness		0.02	0.04
R^{2b}	17.5%	17.3%	17.9%
N	102,666	33,452	34,490
Sigma u	1.055	1.026	1.037
Sigma e	0.665	0.626	0.639
Rho	0.716	0.729	0.725

Statistically significant (* $P = 0.05$; ** $P = 0.01$; *** $P = 0.001$).

^aAll results (coefficients) are net of age, age squared, age cubed, partner status (1–0), unemployment status (1–0), health disability (1–0), being East German (1–0), being foreign born (1–0), life events, the national unemployment rate, and number of years interviewed.

^bThe R^2 reported here is a weighted average of variance accounted for “between persons” and “within persons.”

Table S3. Effects of own life goals and partner's life goals on life satisfaction: GLS random-effects panel regressions (metric coefficients, *P* values based on robust SEs)

	All respondents: own personality + own life goals ^a	Partnered men: own and partner personality + own and partner life goals ^a	Partnered women: own and partner personality + own and partner life goals ^a
Neuroticism	-0.27***	-0.22***	-0.21***
Extroversion	0.06***	0.07***	0.02
Openness	0.05***	0.06**	0.06**
Agreeableness	0.04**	0.04	0.04
Conscientiousness	0.08***	0.08**	0.06*
Partner neuroticism		-0.10***	-0.08**
Partner extroversion		0.02	0.01
Partner openness		0.02	0.03
Partner agreeableness		-0.00	0.05
Partner conscientiousness		-0.02	0.03
Altruistic goals	0.36***	0.37***	0.27***
Family goals	0.26***	0.29***	0.15***
Success goals	-0.21***	-0.21***	-0.18***
Partner altruistic goals		0.07	0.11*
Partner family goals		-0.02	0.24***
Partner success goals		-0.09	-0.05
<i>R</i> ^{2b}	19.9%	19.1%	20.4%
<i>N</i>	70,140	20,690	21,086
Sigma <i>u</i>	1.077	1.052	1.055
Sigma <i>e</i>	0.655	0.612	0.621
Rho	0.730	0.747	0.743

Statistically significant (**P* = 0.05; ***P* = 0.01; ****P* = 0.001).

^aAll results (coefficients) are net of age, age squared, age cubed, partner status (1–0), unemployment status (1–0), health disability (1–0), being East German (1–0), being foreign born (1–0), life events, the national unemployment rate, and number of years interviewed.

^bThe *R*² reported here is a weighted average of variance accounted for “between persons” and “within persons.”

Table S4. Effects of working hours, social participation and healthy lifestyle on life satisfaction: GLS random effects panel regressions (metric coefficients, *P* values based on robust SEs)

	All respondents: own personality + life goals + work hours + social participation + healthy lifestyle ^a	Men: own personality + life goals + work hours + social participation + healthy lifestyle ^a	Women: own personality + life goals + work hours + social participation + healthy lifestyle ^a
Neuroticism	-0.27***	-0.27***	-0.26***
Extroversion	0.06***	0.06***	0.07***
Openness	0.05***	0.05***	0.04**
Agreeableness	0.04**	0.04*	0.04*
Conscientiousness	0.08***	0.09***	0.07***
Altruistic goals	0.33***	0.27***	0.37***
Family goals	0.27***	0.27***	0.26***
Success goals	-0.24***	-0.20***	-0.27***
Used but underworked ^b	-0.10***	-0.09***	-0.09***
Used and overworked ^b	-0.02*	-0.03*	-0.02
Unemployed ^b	-0.39***	-0.51***	-0.30***
Not in labor force ^b	-0.14***	-0.31***	-0.06***
Social participation	0.08***	0.10***	0.07***
Exercise frequency	0.03***	0.03***	0.03***
Underweight ^c	0.06	-0.46*	0.14
Overweight ^c	-0.03	0.01	-0.07
Obese ^c	-0.13***	-0.05	-0.22***
<i>R</i> ^{2d}	21.0%	22.4%	20.3%
<i>N</i>	66,612	32,102	34,510
Sigma u	1.061	1.052	1.066
Sigma e	0.646	0.631	0.658
Rho	0.730	0.735	0.724

Statistically significant (**P* = 0.05; ***P* = 0.01; ****P* = 0.001).

^aAll results (coefficients) are net of age, age squared, age cubed, partner status (1–0), health disability (1–0), being East German (1–0), being foreign born (1–0), life events, the national unemployment rate, and number of years interviewed.

^bReference group: individuals who work within ± 3 h of the working time they prefer.

^cReference group: individuals whose weight is conventionally regarded as "normal."

^dThe *R*² reported here is a weighted average of variance accounted for "between persons" and "within persons."