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Unfair Pay and Health

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Abstract

This paper investigates physiological responses to perceptions of unfair pay. We use an integrated approach exploiting complementarities between controlled lab and representative field data. In a simple principal-agent experiment agents produce revenue by working on a tedious task. Principals decide how this revenue is allocated between themselves and their agents. Throughout the experiment we record agents' heart rate variability, which is an indicator of stress-related impaired cardiac autonomic control and has been shown to predict coronary heart diseases in the long-run. Using three measures of perceived unfairness our findings establish a link between unfair payment and heart rate variability. Building on these findings, we further test for potential adverse health effects of unfair pay using data from a large representative data set. The analysis includes cross-sectional and dynamic panel estimations. Complementary to our experimental findings we find a strong and highly significant negative association between health outcomes, in particular cardiovascular health, and the perception of unfair pay.

Keywords: Fairness, social preferences, inequality, heart rate variability, health, experiments, SOEP.
JEL-Codes: C91, D03, D63, I14

1 Introduction

A large and growing body of evidence suggests that fairness perceptions play an important role in labor relations, affecting work morale, effort provision and market efficiency (see, e.g., Fehr et al., 1993, 1997; Abeler et al., 2010; Charness and Kuhn, 2011; Kube et al., 2012; Cohn et al., forthcoming)[1]. Fairness considerations have also been shown to help reconciling evidence on non-standard effects of minimum wages (Katz and Krueger, 1992; Card, 1995; Falk et al., 2006). While this work has studied behavioral effects of fairness perceptions, the present paper provides evidence on adverse effects of unfair pay at the physiological level. In particular, we investigate the potential impact of unfair pay on stress and adverse health outcomes. To test for the potential link between wage related fairness perceptions, stress and health, we use an integrated approach, combining lab and field data to exploit complementarities of different data sources. We proceed in two steps. First, we report controlled lab evidence to test the hypothesis that unfairness perceptions have a negative effect on heart rate variability (HRV). A low HRV is a stress related early indicator of functional and structural impairments of the cardiovascular system, which increases the probability of future manifest coronary heart disease (see, e.g., Dekker et al., 2000; Steptoe and Marmot, 2002; Gianaros et al., 2005). Second, we analyze data from a large representative data set to study whether our findings from the lab extend to the general population and the real-life labor market, in the sense that perception of unfair pay is related to (specific) health outcomes.

The lab experiment implements a simple principal-agent relationship. The agent produces revenue by working on a tedious task and the principal receives the revenue produced by the agent and decides how to allocate it between the agent and himself. This set-up randomly implements various degrees of unfair pay, where the source of variation is the heterogeneity in generosity of the principals, who are randomly assigned to agents. Agents' HRV is monitored throughout the experiment. The experimental set-up allows us to precisely measure physiological responses, actual payments and revenues as well as agents' fairness perceptions of pay. Our hypothesis to be tested is an inverse relationship between the degree of unfair pay and HRV[2]. The results support this hypothesis. Perceptions of unfair pay are inversely related to agents' HRV, our measure of impaired cardiac autonomic control and, therefore, bear the potential to result in cardiovascular diseases in the long run.

In a second step, we therefore investigate whether the observed mechanism translates into cardiovascular diseases in the long run, in the general population. Specifically, we test the hypothesis of an adverse health effect of unfair pay using data from the German Socio Economic Panel (SOEP), a large data set that is representative for the adult German population (Wagner et al., 2007). We regress employees'

[1]For an overview and related studies, see (Fehr and Gaechter, 2000). The above-cited experimental work is complemented by interview studies with personnel managers (see, e.g., Agell and Lundborg, 1995; Bewley, 1999, 2005). Akerlof (1982) provides an early theoretical analysis of fairness and labor market efficiency.

[2]Note that low heart rate variability is observed, among others, during states of mental stress while enhanced heart rate variability occurs during states of mental relaxation (for details and references, see Section 2). This is why we expect an inverse relationship between unfairness and HRV.

subjective health status on whether they consider their wage as fair or unfair. Controlling for a large set of individual as well as labor market characteristics such as net wages, labor market status, occupational status, firm size and industry, we find a strong and significant association between perceptions of unfair pay and lower subjective general health status. We also perform dynamic panel estimations and find evidence for a Granger causal effect of unfair pay on general health. In light of our lab findings we further hypothesized that adverse health effects should be specific to diseases related to the nervous system and the experience of stress, such as heart disease and high blood pressure. Testing for an effect on specific health outcomes is possible as the SOEP not only elicits subjective responses to general health outcomes but also with respect to specific diseases. Confirming our hypothesis, we find that perceptions of unfair pay are in fact mainly correlated to cardiovascular health outcomes. No such relation is observed for diseases such as cancer or apoplectic stroke. The effects are most pronounced for full-time employees above age 50. This is what we would expect given that the visible occurrence of cardiovascular diseases usually does not start before age 50 (Roger et al., 2012), and experience of unfair pay (the stressor) is likely to be more affective the longer the working experience.

Our findings establish a link between unfair pay and coronary heart disease suggesting that on top of behavioral consequences reported in previous work, perceptions of unfair pay can have important negative physiological consequences with possible welfare implications: The global public health and economic burden of cardiovascular disease is immense. By the year 2020, coronary heart disease, along with major depression, is estimated to be the leading cause of life years lost to premature death and years lived with disability worldwide (Lopez et al., 2006). Moreover, among adult populations of high income countries, coronary heart disease is the leading cause of death, and cost of illness studies estimate that almost one percent of the gross national product is attributable to the direct and indirect costs of coronary heart disease (Liu et al., 2002). On an organizational level our findings suggest that fair pay does not only contribute to higher work moral and motivation, but also to a better health status of employees. In this sense our findings suggest important efficiency consequences of fair wages, additional to efficiency wage arguments (Akerlof, 1982).

The remainder of the paper is organized as follows. In the next section we present our experimental design and results. Section 3 reports results regarding the representative sample, including cross-sectional and dynamic panel estimations. Section 4 concludes.

2 An experiment to study physiological responses to unfair pay

2.1 Experimental design and procedural details

In the experiment we implemented a simple principal-agent relationship. Upon arrival to the lab, subjects were randomly assigned to the role of agent or principal and randomly matched into pairs consisting of one agent and one principal. The interaction was completely anonymous, i.e., at no point subjects learned about the identity of their partner. Subjects received all instructions via computer screen.[3] We used z-Tree as computer software (Fischbacher, 2007). Agents received a pile of numbered sheets. On each sheet there was a table containing a large number of zeros and ones. The work task was to count the correct number of zeros on a given sheet and to enter this number on a computer screen. Total working time was 25 minutes. Each correctly entered number of zeros per sheet created revenue of three Euros. If the entered number was "almost" correct (deviation of plus/minus 1 with respect to the correct number) revenue was one Euro. The accumulated revenue was continuously shown to agents on the screen. Agents were explicitly told that they could complete as many sheets as they wanted to, including completing no sheet at all. Principals were informed that agents created revenue by working on a task. They did not work and were told that they were free to do things like reading newspapers, completing class-work etc.

After completion of the 25 minute working time, each principal was informed about the accumulated revenue created by his agent and was asked to allocate it between himself and the agent. Before the principal's allocation decision was communicated to the agent, the latter was asked to state the amount of money he would consider an "appropriate pay". This information was not revealed to the principal. The agent was then informed about the principal's actual allocation decision. Due to the randomized matching of principals to agents, and the heterogeneity in generosity among principals, our experiment implements a randomized feedback for agents in form of varying revenue allocations. Starting with the revelation of the allocation,the agent was given a time window of 15 minutes to cope with this information.[4] During this time subjects answered a short survey on perceived fairness of the received payment. We used the following item (Fairness question): "In your view, how fair was the return you received from your principal?" Answers were given on a 5-point Likert scale, with higher values indicating that returns were considered less fair.

As physiological measure of agents' autonomic nervous system activity we used heart rate variability (HRV), an established indicator of stress-related activation of the autonomic nervous system (Task Force, 1996; Steptoe and Marmot, 2002)[5]. HRV

[3]Instructions are shown in the Appendix.

[4]This is a standard procedure in HRV studies. Brosschot and Thayer (2003) show that especially negative emotions are related to a relatively long lasting heart rate response.

[5]At the beginning of the experiment a polar F810i device (polar electro OY, Kempele, Finland) was attached to record and store time intervals between consecutive heart beats (inter-beat-interval, IBI). Agents were instructed to remain seated during the whole experiment and try to restrict all movements, with the exception of their dominant arm operating the computer. The target time

reflects the continuous interaction of sympathetic and vagal influence on heart rate, indicating an individual's capacity to generate regulated physiological responses to demanding situations (Appelhans and Luecken, 2006). Low HRV mirrors a decreased vagal tone with sympathetic predominance and is observed, among others, during states of mental stress (von Borell et al., 2007). Conversely, enhanced HRV occurs during states of mental relaxation (Vermunt and Steensma, 2003). A low HRV is an early indicator of functional and structural impairments of the cardiovascular system, which increases the probability of future manifest coronary heart disease (Dekker et al., 2000; Steptoe and Marmot, 2002; Gianaros et al., 2005). In the analysis we use two measures of HRV. The first one serves as a baseline measure (HRV_baseline) and was measured towards the end of the working period but prior to the revelation of the allocation decision. The second one was taken 15 minutes after exposure to the stimulus, i.e., the revelation of the principal's allocation decision. It records the response of the autonomic nervous system to the stimulus and serves as dependent variable (HRV_response).

Subjects were male students from the University of Bonn studying various majors except economics. They gave their informed consent to participate in the experiment. Exclusion criteria were the use of medication with potential interference with cardiovascular function or the presence of a chronic disease condition, such as hypertension, cardiac arrhythmias, coronary heart disease, or diabetes. In total 80 subjects participated in the experiment (40 principals and 40 agents). During the process of data collection, we had to exclude data of 10 subjects in the role of agents, due to incomplete or defective heart rate measurements. The main analysis is thus based on 30 subjects in the role of agents with complete data. Importantly, the 10 subjects who were excluded due to incomplete heart rate measurements were not different to the other subjects, neither in terms of working behavior nor treatment by their principals (see Footnote 7).

2.2 Experimental results.

We are interested in the physiological reactions in response to perception of unfair pay. Fairness perception has by its nature a subjective component (see, e.g., Cappelen et al., 2007; Reuben and Van Winden, 2010). For our measures of perceived fairness we therefore combine (objective) distributional outcomes with (subjective)

window for physiological recordings lasted five minutes. Data were transmitted to a PC, stored, and analyzed offline by a researcher who was blind to the psychological outcome measures. After visualizing and manually correcting data for artefacts a smoothness priors method was used to remove trends of the IBI time series. Then, a HR time series was derived and the following time-domain based HRV indices were calculated: SD-IBI (standard deviation of the IBI series), SD-HR (standard deviation of the HR series), and RMSSD-IBI (root mean square of successive differences of the IBI series) (Niskanen et al., 2004). The RMSSD-IBI represents a sensitive index of parasympathetically-dominated, respiratory related, fast fluctuations of HR, and can be calculated with milliseconds precision. It is considered to accurately index resting vagal tone directed to the heart and was documented to be rather resistant to the biasing effects of breathing (Penttilae et al., 2001). As SD-IBI and SD-HR are highly correlated with RMSSD-IBI we restrict the presentation of findings to RMSSD-IBI, as a robust and well validated time-domain based indicator of parasympathetic cardiac control. All calculations were done with a computer program for advanced HRV analysis (Niskanen et al., 2004).

survey responses. We construct three measures, which include both objective and subjective information. The first measure is simply the difference between a principal's and an agent's payoff. It is informed by fairness theories that model fairness comparisons in terms of deviations from an equitable share[6]. Note that this measure considers wage payments and resulting payoffs only, disregarding effort costs. We have to abstract from effort costs given that in a real effort experiment, effort costs are unknown to the experimenter. The second measure is the difference between the payoff an agent indicated as "appropriate payoff" prior to knowing the actual allocation decision, and the actually received payoff. This measure therefore includes a subjective component of the agent and accounts for fairness perceptions that include both, payoffs as well as effort costs. The third measure concerns answers to the Fairness question, i.e., agents' assessments of how fair they perceived the wage payment of their principals (on a 5-point Likert scale). This measure completely abstracts from observed wage payments and allows for a fully subjective fairness assessment of agents. It is also similar to the survey measure we use in our analysis of the effects of fairness perceptions on health outcomes in the general population. The three measures are highly correlated (Spearman's ρ is between 0.498 and 0.705, $p < 0.01$).

Table 1 reports means and standard deviations of our main variables[7]. On average agents produced total revenue of 20.93 Euro and indicated that they would consider a share of 14.03 Euro (67% of total revenue) as "appropriate payoff". This contrasts sharply with the amounts agents actually received. On average principals allocated 9.53 euros to agents (46% of total revenue).[8] Table 1 further shows the difference in payoffs of principals and agents, as well as the difference between the amounts considered as appropriate and the amounts actually received. Both differences vary considerably among subjects (standard deviations of 4.90 and 4.37, respectively). In other words the experiment generated substantial variation in (perceived) fairness violations, a prerequisite for the analysis of the effect of fairness perceptions on HRV.

[6]See, e.g., Fehr and Schmidt (1999) or Falk and Fischbacher (2006) where fairness or unfairness is evaluated as difference in payoffs (equity as a reference standard).

[7]Table 1 reports data for the 30 subjects with complete heart rate measurement. Subjects with incomplete measurement were not different in any systematic way. Total revenue for this group was 20.20 (Std. dev. 7.23), the payoff allocated to the principal was 11.70 (Std. dev. 3.71), the amount received by the agent 8.50 (Std. dev. 5.23) and the amount seen as appropriate by the agent was 13.80 (Std. dev. 6.34). Kruskal-Wallis rank tests do not reject the null hypothesis that both groups are drawn from the same population (p-values are between 0.54 and 0.98).

[8]Only two agents received more than they indicated as an appropriate amount.

Variable	Mean	Standard Deviation
Total revenue produced by agents (in Euro)	20.93	8.57
Payoff allocated to the principal (in Euro)	11.40	4.19
Payoff received by agent (in Euro)	9.53	5.58
Principal's - agent's payoff (in Euro)	1.87	4.90
Payoff seen as appropriate by the agent	14.03	6.68
Appropriate - actual payoff (in Euro)	4.50	4.37
Fairness question (scale: 1-5)	3.43	1.43

Table 1: Descriptive statistics. $N = 30$; appropriate refers to the amount, which is stated by the agent as appropriate pay after the total revenue was known but before the principal's allocation decision was communicated; the difference between principal's and agent's payoff is our first measure of unfairness, the second is the difference between appropriate and actual payoff and the third is the answer to the Fairness question; answers are given on a 5-point Likert scale and are coded such that higher values imply higher levels of unfairness.

To test our hypothesis of an inverse relationship between the degree of fairness violation and HRV we regress HRV_response on our three measures of unfairness. The results are shown in Table 2. To ease comparison, the measures of unfairness are standardized. All three coefficients are negative and significant, see columns (1), (3) and (5). These results indicate that HRV reacts negatively to perceptions of being treated in an unfair way, i.e., fairness systematically affects the autonomic nervous system. Columns (2), (4) and (6) include two important control variables, HRV_baseline and generated revenue. Controlling for different baseline levels addresses the possibility that subjects with a generally low baseline HRV have, e.g., systematically different fairness expectations or standards, and may therefore perceive payments differently. Likewise, it is important to control for levels of generated revenue to exclude the possibility that principals were willing to share relatively higher amounts with more productive agents. Results in columns (2), (4) and (6) show that our main result is robust to including these controls. While the coefficients of interest are slightly smaller compared to those reported in columns (1), (3) and (5), they remain significant.

	HRV_response					
	(1)	(2)	(3)	(4)	(5)	(6)
Principal's - agent's payoff	-5.361**	-4.717**				
	[1.960]	[1.976]				
Appropriate - actual payoff			-5.781***	-4.363**		
			[1.781]	[1.773]		
Fairness question					-6.514***	-5.724***
					[2.141]	[1.921]
HRV_baseline		0.457***		0.497***		0.491***
		[0.145]		[0.145]		[0.130]
Generated revenue		-0.451*		-0.207		-0.369*
		[0.232]		[0.222]		[0.181]
Constant	32.072***	30.483***	32.072***	24.408***	32.072***	27.927***
	[1.910]	[5.198]	[1.868]	[4.654]	[1.782]	[4.244]
Observations	30	30	30	30	30	30
R-squared	0.214	0.435	0.249	0.434	0.316	0.534

Table 2: Regression analysis on the relation between perceived fairness and HRV. OLS estimates with robust standard errors in brackets. ***, **, * indicate significance at 1-, 5-, and 10-percent level, respectively. The dependent variable is HRV_response, i.e., the heart rate variability, which was measured after exposure to actual payoff. It records the response of the autonomic nervous system to the stimulus. HRV_baseline measures the HRV towards the end of the working period. Appropriate refers to the amount, which is stated by the agent as appropriate pay after the total revenue was known and before the principal's allocation decision was communicated; the difference between principal's and agent's payoff is our first measure of unfairness, the second is the difference between appropriate and actual payoff and the third is the answer to the Fairness question; answers are given on a 5-point Likert scale and are coded such that higher values imply higher levels of unfairness. The unfairness measures are standardized (mean = 0, standard deviation = 1). Generated revenue represents total revenue produced by the agent.

3 Fairness perceptions and health: representative field data

Our experimental data show that perceiving a wage as unfairly low induces impaired cardiac autonomic control. In view of the significance of HRV for stress related cardiovascular health, our results suggest potential effects on health outcomes as a reaction to perceptions of unfair exchange at work. In other words, we would expect that if perceptions of unfair pay constitute a chronic source of stress, unfair pay should be negatively related to employees' general health status and in particular to stress-related diseases. In the following we investigate this issue in the context of the German labor market by analyzing data from the German Socio-Economic Panel (SOEP). Exploiting complementarities between lab and field data is useful in terms of cross validating findings and simultaneously providing evidence that is both, controlled and based on representative data.[9]

The SOEP is a representative panel survey of the adult population living in Germany. All household members above age 17 are interviewed on a wide range of

[9]For a discussion of lab and field data, see Falk and Heckman (2009).

individual and household information and for their attitudes on assorted topics.[10] Each wave records information on the respondents' current labor market status, including wages. Due to data availability our main analysis is based on data of the year 2009 which also include an item regarding perceived fairness of wage payments.[11] The question reads as follows: "Do you consider the income that you get at your current job as fair?" with the possible answers "yes" or "no". Among the roughly 11,000 subjects, who are active in the labor market, about 36% stated that they consider their wage as unfair. The data set also contains items about health status, in particular about subjective health status in general and whether various diseases have been diagnosed in the past. The question about health status in general is: "How would you describe your current health status?" Responses were given on a 5-point scale ranging from "very good" to "bad". For the analysis the variable was coded in a way that higher values indicate better health. For the full sample the mean is 3.55 (standard deviation is 0.86). While subjective health indicators have their limitations, previous research in health economics suggests that responses to subjective health status questions predict labor market outcomes, health impairments and mortality.[12]

A more "objective" measure can be constructed from answers to the question whether a physician has "ever diagnosed" a particular disease, mentioned in a list presented to participants. Analyzing responses to this question is particularly informative as it allows a more precise test of our hypothesis: Since impaired cardiac autonomic control is of particular significance for cardiovascular health, we hypothesized that perceptions of unfair pay predict stress-related diseases such as heart disease and high blood pressure, rather than diseases such as cancer or asthma. Finding selective associations would suggest that the main mechanism how fairness perceptions affect health operates through cardiac control similar to what we find in our lab data.

In Table 3 we report OLS estimates to assess how subjective health status is related to perceptions of unfair pay.[13] Since fairness perceptions may simply reflect relatively low wage levels we control for net wages. We also control for age and gender. Column (1) shows a negative, highly significant coefficient for unfair wage. Thus, respondents who consider their income as unfair report a significantly worse health status. Net wages and age have a significant effect on self-reported health status in the expected directions. Column (2) adds further controls, which may simultaneously affect fairness perceptions and health status, respectively. These

[10]For more details on the SOEP, see www.diw.de/gsoep/ and Wagner et al. (2007), SOEP v28 is used.

[11]Not all items we use are elicited in every wave. Next to the Fairness question which was also asked in 2005, 2007 an 2011, in the year 2009 the questionnaire covers items about particular diseases and personality, which are essential for our analysis. The only exception is body mass index (BMI) which was not elicited in 2009. BMI data are therefore taken from the 2010 wave.

[12]For a comprehensive discussion of the literature, measurement issues, reporting biases and effects on labor market outcomes, see Currie and Madrian (1999). They discuss potential limitations of subjective health measures but also point out that self-reported measures are good indicators of health as they are highly correlated with medically determined health status. The authors thank Janet Currie for suggesting testing for selective associations.

[13]We get the similar results using Ordered Probit estimations.

include marital status, whether the respondent lives in East Germany, labor market experience (part and full time), educational background, firm size, occupational status (e.g., blue collar vs. white collar), type of industry and measures of personality. The complete specification and all coefficients are shown in Table A1 in the Appendix. In column (3) of Table 3 we exclude employees for whom the relation between fairness perception and health status is less plausible. This includes employees who work only part-time and, in particular, the self-employed who largely determine their income themselves. Since visible occurrence of cardiovascular diseases usually does not start before age 50 (Roger et al., 2012), we additionally, in column (4), exclude employees who are younger than 50 years old.

Results in columns (2) and (3) indicate that the unfair wage coefficient is robust with respect to adding various controls and restricting the sample to full-time employees. This means that conditional on wage level, educational background, labor market conditions, industry and labor market status, health status is strongly associated with the perception of receiving an unfairly low wage. As expected, the coefficient is somewhat larger in the specification that excludes part-time and self-employed workers. The fact that the coefficient of interest increases when moving from column (3) to column (4) further indicates that the observed negative relation between unfair pay and subjective health is more pronounced for the work force above age 50. Interestingly, an inspection of all coefficients in columns (2) to (4) of Table A1 in the Appendix reveals that most control variables such as industry or firm size have no systematic effect on health status. The only systematic effect on top of unfair pay, net wages, gender and East German origin is found in respondents' personalities, measured with the Big-5 inventory[14]. The relevance of personality in this context is in line with Conti and Heckman (2010) who provide evidence for the importance of personality in determining health. Conscientiousness, extraversion and agreeableness are all positively related to better health conditions. Neuroticism, on the other hand, is negatively associated with health.

[14]The Big-5 can be broadly classified as follows: Openness to experience (appreciation for art, emotion, adventure, and unusual ideas; imaginative and curious), conscientiousness (a tendency to show self-discipline, act dutifully, and aim for achievement), extraversion (a tendency to seek stimulation and the company of others), agreeableness (a tendency to be compassionate and cooperative rather than suspicious and antagonistic towards others), neuroticism (a tendency to easily experience unpleasant emotions such as anxiety, anger, or depression). See, e.g., Almlund et al. (2011) and Becker et al. (2012) for an overview.

Dependent variable: subjective health status (higher values indicate better health)				
	(1)	(2)	(3)	(4)
Unfair wage	-0.180***	-0.169***	-0.199***	-0.262***
	[0.016]	[0.018]	[0.022]	[0.041]
Net wage/1000	0.054***	0.033***	0.033***	0.032*
	[0.006]	[0.008]	[0.012]	[0.018]
Age	-0.019***	-0.015***	-0.018***	-0.005
	[0.001]	[0.002]	[0.003]	[0.007]
Female	0.013	-0.041*	-0.050*	0.021
	[0.016]	[0.021]	[0.027]	[0.051]
Constant	4.351***	4.334***	4.405***	3.803***
	[0.030]	[0.091]	[0.126]	[0.343]
Further controls	no	yes	yes	yes
Occupational restrictions	no	no	yes	yes
Age restrictions: Age $\geq$ 50	no	no	no	yes
Observations	11,638	9,988	5,892	1,878
R-squared	0.080	0.120	0.132	0.100

Table 3: Relation between subjective health status and fairness perceptions (SOEP). OLS estimates with robust standard errors in brackets. The dependent variable measures subjective health status on a five-point scale from "bad" to "very good". ***, **, * indicate significance at the 1-, 5-, and 10-percent level, respectively. "Unfair wage" is a dummy variable equal to one if the respondent answered the question "Do you consider the income that you get at your current job as fair?" with "no" and zero otherwise. Additional controls include marital status (married (baseline category), single, widowed, divorced), whether the respondent lives in East Germany in 2009, labor market status (working in public sector, tenure, full time and part time experience), dummies for educational background (Hauptschule (baseline category), Realschule, Fachoberschulreife, Abitur, other schooling degree, no schooling degree, missing), dummies for firm size (self-employed, below 5, 6-10, 11-20, 21-100 (baseline category), 101-200, 201-2000, more than 2000, missing), occupational status (unskilled blue collar worker, skilled blue collar (baseline category), blue collar craftsman, blue collar foreman, blue collar master, white collar unskilled, white collar skilled, white collar craftsman, white collar master, white collar high qualified, white collar management, civil servant, civil servant intermediate, civil servant high, civil servant executive, other occupation), industry code (agriculture (baseline category), energy, mining, manufacturing, construction, trade, transport, bank/insurance, services, missing). Controls also include measures of personality (Big-5). The sample in column 1 contains all SOEP participants who are in any way active in the labor market in 2009. The sample in column 2 excludes individuals for whom not all controls are available or who just started in the current firm and whose work related information therefore does not refer to the current employer. The sample in column 3 is additionally restricted to dependent full-time employed individuals with positive income. In addition to the restrictions in column 3, the sample in column 4 is restricted to individuals who are at least 50 years old. For more detailed information see Table A1 in the Appendix.

We complement the cross-sectional analysis and exploit the panel structure of the SOEP to develop dynamic panel data models which allow testing for a Granger causal effect of unfair pay on subjective health. Using Arellano-Bover/Blundell-Bond estimators enables us to estimate the model for the years 2011, 2009 and 2007 (for details on data structure, estimation strategy and estimation results see Appendix). We estimate and validate models with different lag lengths and robustly reject the null hypothesis that the coefficients of lags of unfair wage perception are zero ($p < 0.05$ in all specifications, see Table A2). This indicates a Granger causal effect of unfair wage perceptions on subjective health. The results are robust for

reducing or increasing the lag lengths of subjective health or extending the model by adding lags of net wages.

We now move on to the analysis of specific diseases. Table 4 summarizes results from regressions for eight specific diseases listed in the SOEP survey 2009.[15] In addition we constructed a Body Mass Index (BMI) as an additional "objective" health outcome.[16] In Table 4 we use the same specifications as in columns (1) to (4) of Table 3. Since, with the exception of BMI, outcomes are binary (diagnosed vs. not diagnosed) we use Probit estimates and report average marginal effects. We hypothesized that the unfair wage coefficient should be selectively significant for diseases that are related to stress and impaired cardiac control and especially pronounced for employees older than 50. This is largely what we find: Perceptions of fairness have a highly significant effect on stress-related diseases such as heart disease, high blood pressure, diabetes[17] and high BMI. In contrast, we find only weak or insignificant associations for depression, cancer, asthma, apoplectic stroke or migraine. Comparing columns (3) and (4) in Table 4 reveals that the size of the effects concerning heart disease, high blood pressure and diabetes doubles if restricting the sample to employees above age 50. Apparently, and similar to our findings in Table 3, effects concerning unfair pay and health are driven in particular by older employees. Summarizing, we find selective associations yielding complementary evidence with respect to our findings from the lab.

	Marginal effects of unfair wage			
Disease (Share/mean)	(1)	(2)	(3)	(4)
Heart disease (3.3%)	0.011***	0.013***	0.018***	0.033**
High blood pressure (15.2%)	0.020***	0.019**	0.028***	0.067***
Diabetes (3.2%)	0.008**	0.010***	0.018***	0.033***
Depression (3.9%)	0.008**	0.006	0.007	0.009
Cancer (2.0%)	-0.003	-0.004	0.007*	0.003
Asthma (4.2%)	-0.000	-0.001	0.001	0.016*
Apoplectic stroke (0.5%)	-0.001	-0.001	0.003	0.009
Migraine (5.4%)	0.007	0.006	0.007	0.016*
Body Mass Index (26.0 kg/m^2) (OLS)	0.410***	0.350***	0.305**	0.424*
Further controls	no	yes	yes	yes
Occupational restrictions	no	no	yes	yes
Age restrictions: Age $\geq$ 50	no	no	no	yes

Table 4: Relation between specific diseases and unfairness perceptions (SOEP). Regression models (1) to (4) refer to the exact same specifications as in columns (1) to (4) in Table 3. We use Probit estimations, reporting average marginal effects, except for Body Mass Index (OLS). Percentages and the BMI mean are related to the full sample in column (1). ***, **, * indicate significance of the "Unfair wage" coefficient at the 1-, 5-, and 10-percent level, respectively.

[15]The indication of dementia was also asked for but dementia was excluded from the analysis since less than 0.03% of the working individuals indicated this disease. All regressions are available on request. Note that the data structure of the SOEP does not allow constructing a dynamic panel data model for specific diseases because questions regarding specific diseases were only asked in 2009 and 2011.

[16]BMI is often used as a health indicator, see Currie and Madrian (1999).

[17]The questionnaire asked for diabetes in general, there is no information about different types. Eriksson et al. (2008) suggest that mainly diabetes type II is related to psychological distress.

4 Concluding remarks

In this paper we establish a link between the experience of unfair pay and heart rate variability: Higher levels of perceived unfairness go along with lower heart rate variability. Low heart rate variability reflects stress and an impaired balance between the sympathetic and the vagal nervous system, and has been shown to predict coronary heart disease in the long-run. Using a large representative data set (SOEP) we therefore test whether perceptions of unfair pay predict adverse health outcomes in the general population. Our findings suggest that health status is in fact negatively correlated with subjective perceptions of unfair pay. To complement the cross-sectional analysis we exploit the panel dimension of the SOEP, develop dynamic panel data models and provide evidence for a Granger causal effect of unfair pay on health outcomes. Moreover, we find selective associations for specific health outcomes that are predicted if the mechanism operates through the nervous system. Adverse health effects turn out to be most pronounced for full-time employees who are older than 50 years.

Our findings are related to a literature that points out behavioral effects of fairness in labor relations. We show that perceptions of unfair pay not only affect the efficiency of labor relations in reducing work morale (e.g., Fehr et al., 1997), but also by potentially affecting the health status of the workforce. Our work is also related to research that uses a very different methodological approach: Studies in epidemiology suggest that people who are confined to demanding jobs that fail to compensate efforts by "adequate" rewards are at increased risk of suffering from stress-related disorders (Siegrist, 2005). Other studies suggest that economic inequality in general contributes to adverse health status.[18]

On a more general level our findings provide evidence that the human body registers and systematically processes social and contextual information. This is related, e.g., to findings in Fliessbach et al. (2007) who show that the human brain encodes social comparison. Using fMRI they report that for a given own wage, receiving a wage that is lower than that of another subject is associated with a significantly lower activation in reward-related brain areas, in particular the ventral striatum. In our representative data analysis we show that on top of actual life circumstances and outcomes, such as net wages, mere perceptions of unfair treatment induce adverse physiological responses. Given that health affects labor market outcomes (see, e.g., Currie and Madrian, 1999), this suggests an important potential feedback mechanism: Labor market experience can induce perceptions of unfairness with consequences for health, which in turn affects labor market outcomes. The feedback mechanism between social environment, perceptions and body responses suggests a potential vicious circle and complementary effects. We may thus have to think about some aspects of labor markets differently, with the fairness-health link potentially leading to a vicious circle involving poor pay and poor health. We believe this question deserved attention in future work.

[18]This was documented in epidemiological investigations using different indicators such as low income (McDonough et al., 1997), income inequality (Kennedy et al., 1996), or perceived unfairness (Bosma et al., 1998; Kivimaeki et al., 2002; Kuper et al., 2002; Lynch et al., 1997). Wilkinson et al. (2011) discuss large-scale effects of inequality.

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Appendix

Additional Tables and Figues

Table A1: Relation between subjective health status and fairness perceptions (SOEP)

Dependent variable: subjective health status (higher values indicate better health)				
	(1)	(2)	(3)	(4)
Unfair wage	-0.180***	-0.169***	-0.199***	-0.262***
	[0.016]	[0.018]	[0.022]	[0.041]
Net wage /1000	0.054***	0.033***	0.033***	0.032*
	[0.006]	[0.008]	[0.012]	[0.018]
Age	-0.019***	-0.015***	-0.018***	-0.005
	[0.001]	[0.002]	[0.003]	[0.007]
Female	0.013	-0.041*	-0.050*	0.021
	[0.016]	[0.021]	[0.027]	[0.051]
Public sector		-0.042*	-0.013	0.097
		[0.025]	[0.033]	[0.062]
Tenure		0.000	0.000	-0.001
		[0.001]	[0.001]	[0.002]
Experience full time		-0.006***	-0.005	-0.006
		[0.002]	[0.003]	[0.005]
Experience part time		-0.003	-0.000	-0.001
		[0.003]	[0.005]	[0.007]
Realschule		0.029	-0.007	-0.014
		[0.024]	[0.031]	[0.057]
Fachoberschulreife		0.017	-0.022	-0.164*
		[0.038]	[0.050]	[0.087]
Abitur		0.059**	0.030	-0.069
		[0.030]	[0.041]	[0.073]
Other schooling degree		0.050	0.001	0.049
		[0.041]	[0.053]	[0.086]
No degree		-0.106	-0.169	0.427***
		[0.086]	[0.123]	[0.165]
In school		0.056	0.181***	
		[0.127]	[0.052]	
School info missing		0.028	0.018	0.033
		[0.052]	[0.075]	[0.121]
Lives in East Germany		0.030	0.078***	0.136***
		[0.020]	[0.026]	[0.050]
Self employed		0.069		
		[0.053]		
Firm size < 5		0.066*	0.054	0.051
		[0.034]	[0.054]	[0.109]
Firm size 6-10		0.017	0.015	-0.008
		[0.033]	[0.046]	[0.100]
Firm size 10-20		0.032	0.009	-0.062
		[0.035]	[0.045]	[0.092]
Firm size 101-200		0.022	0.062	0.102
		[0.033]	[0.040]	[0.071]
Firm size 201-2000		0.024	0.026	0.010
		[0.026]	[0.031]	[0.055]
Firm size above 2000		-0.005	0.017	0.028
		[0.027]	[0.032]	[0.058]

Firm size missing	-0.016	0.023	0.130
	[0.104]	[0.150]	[0.150]
Blue collar unskilled	-0.038	-0.024	0.053
	[0.052]	[0.085]	[0.133]
Blue collar craftsman	-0.003	-0.042	-0.022
	[0.037]	[0.043]	[0.082]
Blue collar foreman	-0.068	-0.095	-0.112
	[0.061]	[0.065]	[0.115]
Blue collar master	0.162	0.110	0.302
	[0.103]	[0.106]	[0.214]
White collar master	-0.119	-0.188	-0.232
	[0.123]	[0.130]	[0.186]
White collar skilled	0.016	-0.017	-0.010
	[0.041]	[0.056]	[0.110]
White collar unskilled	0.027	-0.056	-0.192
	[0.051]	[0.081]	[0.147]
White collar craftsman	0.093***	0.051	0.082
	[0.035]	[0.043]	[0.077]
White collar high qualified	0.141***	0.107**	0.176**
	[0.039]	[0.048]	[0.087]
White collar manager	0.046	0.038	0.180
	[0.067]	[0.079]	[0.135]
Civil servant low	0.385***	0.360**	-0.231*
	[0.142]	[0.159]	[0.123]
Civil servant intermediate	0.062	-0.028	-0.103
	[0.082]	[0.088]	[0.147]
Civil servant high	0.101*	0.091	0.119
	[0.061]	[0.073]	[0.116]
Civil servant excecutive	0.138**	0.091	0.139
	[0.069]	[0.084]	[0.126]
Other occupation	0.072*	-0.040	
	[0.040]	[0.140]	
Single	0.004	0.006	-0.034
	[0.023]	[0.029]	[0.092]
Widowed	0.032	0.010	-0.086
	[0.070]	[0.111]	[0.132]
Divorced	0.010	0.018	0.009
	[0.036]	[0.044]	[0.069]
Industry missing	-0.125	-0.066	0.005
	[0.081]	[0.116]	[0.177]
Industry energy	-0.139	-0.050	-0.015
	[0.088]	[0.108]	[0.184]
Industry mining	-0.234	-0.279**	-0.476***
	[0.145]	[0.132]	[0.172]
Industry manufacturing	-0.112*	-0.062	-0.139
	[0.064]	[0.088]	[0.137]
Industry construction	-0.107*	-0.015	-0.039
	[0.065]	[0.088]	[0.139]
Industry trade	-0.134**	-0.018	-0.102
	[0.065]	[0.090]	[0.150]
Industry transport	-0.189**	-0.094	-0.136
	[0.074]	[0.097]	[0.153]
Industry bank/insurance	-0.131*	-0.084	-0.280*
	[0.073]	[0.100]	[0.167]
Industry services	-0.114*	-0.041	-0.177

		[0.063]	[0.088]	[0.138]
Openness		0.016*	0.019	0.022
		[0.010]	[0.013]	[0.023]
Conscientiousness		0.064***	0.077***	0.036
		[0.010]	[0.012]	[0.024]
Extraversion		0.021**	0.016	0.022
		[0.009]	[0.012]	[0.022]
Agreeableness		0.049***	0.051***	0.113***
		[0.009]	[0.011]	[0.020]
Neuroticism		-0.103***	-0.102***	-0.115***
		[0.009]	[0.011]	[0.021]
	4.351***	4.334***	4.405***	3.803***
Constant	[0.030]	[0.091]	[0.126]	[0.343]
Observations	11,638	9,988	5,892	1,878
R-squared	0.080	0.120	0.132	0.100

OLS estimates with robust standard errors in brackets. The dependent variable measures subjective health status on a five-point scale from "bad" to "very good". ***, **, * indicate significance at the 1-, 5-, and 10-percent level, respectively. "Unfair wage" is a dummy variable equal to one if the respondent answered the question "Do you consider the income that you get at your current job as fair?" with "no" and zero otherwise. Additional controls include marital status (married (baseline category), single, widowed, divorced), whether the respondent lives in East Germany in 2009, labor market status (working in public sector, tenure, full time and part time experience), dummies for educational background (Hauptschule (baseline category), Realschule, Fachoberschulreife, Abitur, other schooling degree, no schooling degree, missing), dummies for firm size (self-employed, below 5, 6-10, 11-20, 21-100 (baseline category), 101-200, 201-2000, more than 2000, missing), occupational status (unskilled blue collar worker, skilled blue collar (baseline category), blue collar craftsman, blue collar foreman, blue collar master, white collar unskilled, white collar skilled, white collar craftsman, white collar master, white collar high qualified, white collar management, civil servant, civil servant intermediate, civil servant high, civil servant executive, other occupation), industry code (agriculture (baseline category), energy, mining, manufacturing, construction, trade, transport, bank/insurance, services, missing). Controls also include measures of personality (Big-5). The sample in column (1) contains all SOEP participants who are in any way active in the labor market in 2009. The sample in column (2) excludes individuals for whom not all controls are available or who just started in the current firm and whose work related information therefore does not refer to the current employer. The sample in column (3) is additionally restricted to dependent full-time employed individuals with positive income. In addition to the restrictions in column 3, the sample in column (4) is additionally restricted to individuals who are at least 50 years old. ***, **, * indicate significance of the "Unfair wage" coefficient at the 1-, 5-, and 10-percent level, respectively.

Panel data analysis

We complement the cross-sectional analysis and exploit the panel structure of the SOEP to develop dynamic panel data models which allow testing for a Granger causal effect of unfair pay on health outcomes. Causality in the sense of Granger (1969) implies that a potential effect from x on y is absent if lagged values of x_t add no further information to explain y_t beyond lagged values of y_t itself.[19]

The bivariate dynamic panel data model we use is adapted from Holtz-Eakin et al. (1988) and allows for individual fixed effects,

$$H_{it} = \sum_{l=1}^{h} \beta_l H_{it-l} + \sum_{j=1}^{k} \delta_j U_{it-j} + I_i + Y_t + u_{it} \quad (1)$$

where H_{it} is subjective health of individual i in period t ($i = 1, \ldots, N; t = 1, \ldots T$). H_{it} is explained by its own lags, the lags of the individual's perception of unfair pay (U_{it}), an individual fixed effect (I_i) and year dummies (Y_t); h denotes lag lengths of subjective health and k denotes lag lengths of fairness perception. The null hypothesis to be tested is that there exists no Granger causal effect of unfair wage perceptions on subjective health, i.e., that all δ_j are equal to zero.

The data structure of the SOEP does not allow constructing a dynamic panel data model for specific diseases because questions regarding specific diseases were only asked in 2009 and 2011. The question concerning subjective health status, however, was asked more often and we use data from 2001 to 2011. The survey question regarding perception of unfair pay (see section 3) was asked in the SOEP in the years 2009, 2007 and 2005. This data structure determines the period length to be two years which is conservative concerning the detection of Granger causality since causality may become effective faster than that, but using two-years-lags is common in health economics (see e.g., Michaud and Van Soest (2008)). Given this data structure, to maximize the number of estimable time periods and to hold the model as flexible as possible, we fix the number of lags of unfair pay perception (k) to one and calibrate the model by varying j, the number of lags of subjective health status. Using Arellano-Bover/Blundell-Bond estimators enables us to estimate the model for the years 2011, 2009 and 2007, with up to three lags of subjective health status.[20] In light of the medical literature (Roger et al., 2012) and our results in Table 3 (compare columns 3 and 4), we expect to observe the dynamic relation between health and unfair pay in particular for full-time employees who are older than 50 years. Therefore, we construct a balanced panel of individuals who work as full-time dependent employees in the years 2011, 2009 and 2007, and are born in 1961 or earlier. Thus, every individual in the sample is at least 50 years old in one or more periods. Estimation results are presented in Table A2. The estimation shown in column 1 includes one lag of subjective health; the estimations in columns 2 and 3 include two and three lags, respectively. The Hannan-Quinn information criterion

[19] For an interpretation and discussion of Granger causality, see Hamilton (1994).

[20] For validity of these estimators we have to assume that there is no serial correlation in the idiosyncratic errors . We cannot test for this assumption since the data structure limits our model to $T = 3$, and testing it requires $T \geq 5$ (Arellano and Bond, 1991).

Andrews and Lu (2001) selects the model with two lags of subjective health status (column 2) as preferred specification and the Sargan test of overidentification does not reject the validity of the instrumental variables in this specification ($p = 0.187$). A t-test rejects the null hypothesis that the coefficient of the lag of unfair wage perception is zero ($p = 0.025$) and therefore indicates a Granger causal effect of unfair wage perceptions on subjective health. This result is robust for reducing or increasing the lag lengths of subjective health (column 1 and 3) or extending the model by adding lags of net wages.[21]

Table A2: Dynamic panel estimation on the relation between perception of unfair pay and subjective health status

Dependent variable: subjective health status (higher values indicate better health)			
	(1)	(2)	(3)
Subjective Health$_{t-1}$	0.100***	0.170***	0.195***
	[0.021]	[0.038]	[0.052]
Subjective Health$_{t-2}$		0.072**	0.092**
		[0.032]	[0.044]
Subjective Health$_{t-3}$			0.022
			[0.030]
Unfair Wage$_{t-1}$	-0.089**	-0.092**	-0.094**
	[0.040]	[0.041]	[0.042]
Time Dummies	Yes	Yes	Yes
Sargan statistic	21.10**	14.91	14.07
Hannan-Quinn IC	-26.16	-28.41	-25.31
Number of Individuals	1,292	1,292	1,292

Arellano-Bover/Blundell-Bond linear dynamic panel estimations with standard errors in brackets. The balanced sample is restricted to dependent full-time employees who are born in 1961 or earlier. ***, **, * indicate significance at the 1-, 5-, and 10-percent level, respectively.

[21] For example, adding one lag of net wage to the specification in column 2 of Table A2 does basically not change coefficients. While the lag of unfair wage is significant ($p = 0.021$), the lag of net wage is insignificant ($p = 0.943$). Results are available upon request.

Instructions of the experiment

In the following we present a translation of the original German "employee" instructions.

Instructions for Employees

You are now taking part in an economic experiment. Please read the following instructions carefully. Everything that you need to know to participate in this experiment is explained below. Should you have any difficulties in understanding these instructions please notify us. We will answer your questions at your cubicle.
During the course of the experiment you can earn money. The amount of money that you earn during the experiment depends on your decisions and the decisions of another participant. At the end of the experiment you will receive the sum of money that you earned during the experiment in cash.
Please note that communication between participants is strictly prohibited during the experiment. In addition we would like to point out that you may only use the computer functions, which are required for the experiment. Communication between participants and unnecessary interference with computers will lead to exclusion from the experiment. In case you have any questions we are glad to assist you.
The participants of this experiment were randomly assigned the roles of employers and employees. You are an employee for the entire course of the experiment.
In the following you can earn money by working on a task. The money you earn will be received by your employer, who decides on how to divide the money between him and you. The interaction is completely anonymous, i.e., at no point you will learn the identity of the employer and the employer will not learn your identity.

Your work task

The work task is to count the correct number of zeros on prepared sheets containing zeros and ones. At your cubicle you find an example of such a sheet. At the top you see the sheet number. Below that you find a table with zeros and ones. To earn money, you have to count the correct number of zeros and enter it into the computer. To do that you will receive a new computer screen for each sheet.
The first input screen is for the first sheet. Under the heading: "How many zeros are on sheet 1?" you find a box where you can enter a number. Type the correct number into that box and click on "OK". As soon as you have clicked on the "OK"-button, the screen for the next sheet appears etc.
As long as you have not clicked on the OK-button, you can change your entry. As soon as you have clicked on OK, however, the next screen appears.
For each correctly solved sheet you create revenue of 3 Euro. For example, if there are 29 zeros on a particular sheet and you type 29, you create revenue of 3 Euro. If your entry deviates by plus/minus 1 from the correct number of zeros, you receive 1 Euro. If your entry deviates by more than plus/minus 1, you create no revenue for that particular sheet.

Example:
Suppose, the correct number of zeros on a particular sheet is 15.
If you type 15, you create revenue of 3 Euro.
If you type in either 14 or 16, you create revenue of 1 Euro.
If you type in a number smaller than 14 or larger than 16, you create revenue of zero Euro.

Please note: As soon you have clicked OK, you cannot revise your entry anymore. The next screen for the next sheet appears immediately.

On each input screen you are informed about the number of correctly solved sheets, the number of almost correctly solved sheets (deviation plus/minus 1) as well as the resulting amount of revenue you have produced. In addition you see on the screen the remaining time in seconds.
You have 25 minutes to solve sheets and create revenue (25 minutes = 1500 seconds).
You can work on as many sheets as you like: None, one, two etc. up to a maximum of 20. The sheets will be allocated as soon as you have read the instructions.

The decision of the employer

Your employer will receive the amount of money you have produced. He divides the amount of money between himself and you. Any feasible allocation is possible. For example, the employer can keep the whole amount for himself, give the whole amount to you, he can keep 10 percent of the amount and give you 90 percent, he can divide exactly equally etc.
The employer does not work and does not create any revenue. He knows, however, that the amount of money that he can divide depends on your work effort.
Following your working time and the allocation decision of the employer, you will have to complete a short questionnaire. Then, the experiment is over and you will receive your payments in cash, depending on the amount of money and the allocation decision. If you have any questions, please let us know.
If you have read these instructions, please click “Start”.