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Abstract

Environmental stressors such as noise, pollution, extreme temperatures, or crowding can pose relevant externalities in the economy if certain conditions are met. This paper presents experimental evidence that exposure to acute ambient noise decreases cooperative behavior in a standard linear public good game.

JEL Classifications: H41, Q53

Keywords: private provision of public goods; environmental stress; noise

1 Introduction

Traditionally, economics has been abstracting economic behavior from the influence of environmental stressors[1] on humans, much as it used to do for the influence of moods and emotions (Kirchsteiger et al. 2006). In particular, researchers have assumed either that individual preferences are invariant to any impact of environmental stress or that the potential effect on preferences is stochastic and negligible. Environmental stressors may become relevant to economics, however, if three conditions are fulfilled: (1) The effect of environmental stressors on economic behavior is significant, (2) the ambient levels of environmental stressors are subject to (permanent) change (Rabin 1998),[2] and (3) adaptation of humans to altered levels is imperfect or costly.

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[1] Noise, air pollution, extreme temperatures, and crowding have been typically subsumed under environmental stressors (Evans 1984).

[2] For example, the populations of industrialized countries have been subject to considerable variations in ambient levels of noise, pollution, and crowding for the past two centuries, especially in urban areas.

As a first step to this agenda, this paper addresses condition (1) and tests for an aftereffect of acute noise exposure on cooperative behavior in a standard linear public good experiment. One reason for investigating noise among the available set of environmental stressors is that it has been suggested to be the most important stressor for conditions of environmental overload (Moser 1988). To my knowledge, neither noise nor other environmental stressors have been subject to systematic research in economic experiments so far. While I am therefore not aware of previous results regarding an effect of ambient noise on cooperative behavior in social dilemmas, such as the voluntary provision of public goods, the psychological literature reports that acute exposure to noise reduces helping behavior, both in laboratory (Glass and Singer 1972, Sherrod and Downs 1974) and in field experiments (Page 1977, Moser 1988). Helping behavior and cooperative behavior in social dilemmas are related in that altruism has been suggested to be a major motivational driver for behavior in both situations (e.g. Andreoni 2006). Thus, assuming that exposure to noise affects the altruistic component of motivation, the immediate hypothesis for the question of an effect of noise in a public good experiment is that observed cooperation will *decline*.

The literature also provides evidence for the opposite hypothesis, however, if one takes into account possible physiological pathways mediating the potential effect of noise on cooperation. Traditionally, the effects of environmental stressors have been linked to *physiological* stress. Thus, one immediately plausible mechanism would be that noise produces physiological stress, and that physiological stress affects cooperative behavior or altruism. Regarding the first part of this pathway, the early literature on environmental stressors, which focused on *behavioral* measures of physiological stress, found that noise decreases frustration tolerance and attention (Glass and Singer 1972, Sherrod and Downs 1974, Page 1977). Evidence on a link of noise and *physiological* measures of stress, which are typically elevations in the cardiovascular and neuroendocrine systems, is more rare. A meta study by Dickerson and Kemeny (2004) on the effect of various psychological stressors on the stress hormone cortisol does not find a significant effect for noise. However, as the authors note, the sample size is small in the case of noise (n=6). A result where physiological stress from noise could be identified is the "effort-by-stress tradeoff" (Tafalla and Evans 1997, Evans and Cohen 2004): Noise increases norepinephrine and cortisol levels in a laboratory setting if accompanied with high effort to complete a simultaneous task. At the same time, performance in the task is unaffected by noise. If completing the task is associated with low effort, however, no physiological indication of stress under noise can be observed, while performance is significantly worse. Thus, physiological stress seems to be traded-off for effort and produced only if needed to compensate for the increased psychological demands from noise in order to maintain performance. Evidence for the effort-by-stress tradeoff was also found in field studies on job demand and occupational noise (Evans and Cohen 2004). A second result where noise was found to cause physiological stress was in the case of chronic exposure: In studies with children, chronic exposure to aircraft or traffic noise increased cortisol and epinephrine as well as blood pressure levels, adversely affected psychophysiological, cognitive, motivational, and affective indices of stress, and led to decreased persistence in problem solving tasks (Evans et al. 1995, Bullinger et al. 1999, Evans and Cohen 2004).[3]

Regarding the second part of the hypothesized link between noise, physiological stress, and cooperation/altruism, evidence is even more sparse. In an early study, Dovidio and Morris (1975) show that a high-stress condition leads to increased helping behavior towards others who share the same stressful situation. They observed less helping behavior, however, if the potential recipient was in a dissimilar and less stressful situation.[4] To my knowledge, there is only one paper investigating behavior in standard economic games: von Dawans et al. (2012) show that physiological stress, induced by a standardized laboratory stressor, is associated with increased pro-social and altruistic behavior in versions of the trust game and the dictator game. Taking together this evidence with that on the link between noise and physiological stress described above, there is reason to expect a *positive* effect of noise exposure on public good contributions if one assumes that physiological stress mediates the effect.

In the experiment reported in this paper, treated subjects were exposed to a con-

[3]Some of these papers experimentally exploited airport openings that corresponded to natural experiments.

[4]These results found for male subjects were confirmed for female participants by Hayden et al. (1984)

glomerate of typical urban sounds directly before playing a standard linear public good game in groups of four players. The data suggest a *negative* effect of acute noise exposure on public good contributions, compared to an unexposed control group of subjects, and would thus support the first of the two aforementioned hypotheses. The effect is statistically significant for certain subgroups among the student subjects, specifically, Bachelor and Master students, but not for students pursuing other degrees. The effect is not significantly different between men and women. While it is beyond the scope of this paper to further disentangle the motivational drivers or physiological mediators of the noise effect, the present study collects some survey-based controls for chronic, acute pre-experimental, and acute intra-experimental stress as well as for subjects' history of chronic and acute pre-experimental noise exposure in order to account for adaptation or multiple-stressor effects. Most of these variables, in particular chronic stress and noise history, do not significantly interact with the observed effect of noise. Likewise, there is no significant evidence for an effort-by-stress trade-off based on these survey measures. Evidence on an effect from the presence of multiple stressors is mixed, and the possibility of endogeneity inherent to ex post survey measures cannot be excluded.

The paper proceeds as follows. Section 2 presents the experimental design. Section 3 presents the results, and Section 4 concludes.

2 Method

Participants Participants were 63 female and 49 male students at Heidelberg University, recruited via ORSEE (Greiner 2004). 64 subjects were randomly assigned to the noise treatment, 48 subjects to the control treatment. The share of females is somewhat higher in the control treatment (64.6% vs. 50%), which turns out not to be significantly different using two-sided tests. Half of the subjects majors in an academic subject of the social sciences (economics, political science, sociology) while the other half majors in subjects belonging to the humanities, sciences, or another area. Subjects of the social sciences turn out to be unequally distributed across treatments, with a share of 62.5% in the noise treatment but only 33.3% in the control group (Table 1). Likewise, differences

Table 1: Share of students in the social sciences and pursued degrees, by treatments

	Major belongs to social sciences	Degree pursued			
		Bachelor	Master	Staatsexamen[a]	Other, or no answer
Noise	62.5%	70.3%	6.3%	18.8%	4.7%
Control	33.3%	43.8%	22.9%	29.2%	4.2%

Notes: [a] The *Staatsexamen* is a degree in Germany issued by the government, not the university. For examples, teachers, lawyers, and medical doctors graduate via *Staatsexamen*.

exist with respect to the degree pursued. The unequal distributions are likely to be due to the sample size, as the procedure of matching treatment condition and experimental sessions was not systematic. The differences can be a problem for simple tests of the treatment effect if economics students display systematically different behavior, or if academic maturity matters, and thus calls for an additional regression analysis. Mean earnings were €8.40 per subject (SD €1.01), including a fixed show-up fee of €3.

Noise treatment In the first part of the experiment, subjects who received the noise treatment were exposed to 25min of noise at about 65dB(A) on average with bursts at about 75dB(A) on average.[5] The noise was administered through speakers[6] (Glass and Singer 1972, Sherrod and Downs 1974, Tafalla and Evans 1997) placed such that noise levels were fairly equal across cubicles in the lab. Loudness was measured several times during exposure.[7] The noise was a mixture of typical urban sounds at varying levels (such as road traffic, aircraft sound, a drilling jackhammer[8], a ringing cellphone, and passing people engaged in a indiscernible chat) which was interrupted by random bursts of electronic static.[9] During exposure, subjects had to perform a paid proofreading task on four magazine or newspaper articles on various unrelated topics. Payment in this part was conditioned on performance in the task. The control group performed the same task for the same time without being exposed to noise. The typical noise level in

[5]Following the guidelines of the German Association of Otolaryngologists, the noise would not exceed 85dB(A).

[6]Bose Companion 2.

[7]Trotec BS15.

[8]Referential note: "Builders drilling sound" recorded by Koops.

[9]Cohen (1980) reviews several papers using different types of noise. Results suggest that besides the uncontrollability of the noise, the unpredictability matters for an effect of intermittent noise samples while variations in the intensity of the noise matters for an effect of continuous noise samples. The noise administered in the present experiment combines both types using unpredictable, interrupting bursts and variations in intensity of the continuous parts.

the laboratory in sessions in the control treatment was about 45dB(A).

Administering the noise during an unrelated effortful task prior to the public good game is guided by two findings of the literature. First, there is stronger evidence of behavioral aftereffects than of simultaneous effects for noise and other environmental stressors. In Glass and Singer (1972) and Sherrod and Downs (1974), for example, subjects were confronted with an opportunity to display helping behavior after being exposed to noise during which they were working on some other task. While performance in the task did not significantly differ between the treatment and the control group, differences manifested in the behavior afterwards. This suggests that subjects may adapt during exposure.[10] Glass and Singer (1972) and many replications in the literature (see Evans and Cohen 2004) found similar behavioral aftereffects for other environmental stressors and for different tasks following exposure, for instance, persistence in a puzzle task or performance in a proofreading task. However, the dominance of aftereffects does not preclude to also find simultaneous effects: For the relevant case of helping behavior, for example, Page (1977) identifies differences during acute exposure. The second reason for having subjects solve a cognitively demanding task during noise exposure is to allow an effort-by-stress tradeoff to manifest, if present. One way to interpret aftereffects is in the context of behavior that occurs after a daily routine in an exposed environment, e.g., changes in home life from a noisy working environment (Evans and Cohen 2004).

Public good game The public good game was played directly after the proofreading task, in groups of four subjects and for ten periods. The game was of the standard linear type using the voluntary contribution mechanism (VCM). The choice was framed as distributing the endowment of 20 "points" of each round (worth €0.30) between a "private account" and a "group account", the latter yielding a marginal per capita return (MPCR) of 0.4. Matching was constant across rounds (partner treatment) and earnings of each round added to the final payoff. Instructions included a table illustrating a subject's round earnings for various combinations of own and others' contributions to

[10] This is in line with others' findings regarding the effect of simultaneous noise on cognitive performance (e.g. Hancock and Pierce 1985, Hygge and Knez 2001).

the group account.[11]

Questionnaire The experiment concluded with a questionnaire collecting measures of subjective effort in the proofreading task, perceived stress, history of noise exposure, and some demographics. The question in which subjects have to rank their effort put in the proofreading task serves as a control for the presence of physiological stress during noise exposure (Tafalla and Evans 1997). To control for background levels of chronic and pre-experimental stress, the questionnaire used the 4-item version of the Perceived Stress Scale (PSS) by Cohen et al. (1983) as well as a simple question asking for perceived stress on the same day prior to the experiment, respectively. Questions regarding noise asked how bothered the subject felt by the experimental noise (Sherrod and Downs 1974) as well as a subjective ranking of the noise exposure on the same day prior to the experiment, during the past year, and during childhood. Although subjective in nature, collecting some long-term history of noise exposure can serve as a control for "adaptation level shifts" through which noise might be perceived less annoying if a subject has a history of chronic exposure (Berglund et al. 1975, Evans and Cohen 2004). Likewise, the questions about perceived stress and noise exposure right before the experiment can serve as controls for the presence of multiple stressors which could increase the effect of noise due to "diminished coping with multiple stressors" (Evans and Cohen 2004).

Protocol The experiment consisted of seven experimental sessions, conducted in Spring 2013 in the experimental laboratory of the Department of Economics at Heidelberg University, Germany. Each session was scheduled for 1 hour and 15 minutes including seating and payment, which turned out to be about the time each session took. After seating, subjects read the instructions (in hardcopy) for both parts of the experiment in private. The experimenter afterwards paraphrased the important parts of the instructions in a standardized way, with an emphasis on the understanding of the public good game, including the payoff table. Subjects had the opportunity to ask questions in private. When all questions were answered, the texts for the proofreading task were distributed

[11] See the appendix for the exact wording of the instructions (in German, translation to English available upon request from the author).

in hard copy and the experiment started. All other elements of the experiment were programmed and conducted with the software z-Tree (Fischbacher 2007). Subjects were not informed about their earnings in the proofreading task before finishing the end of the experiment. After finishing the questionnaire, subjects were paid and dismissed.

3 Results

3.1 Nonparametric treatment effects

Before investigating an aftereffect in the public good game, it is meaningful to evaluate the reception of the noise treatment during exposure. In the proofreading task, subjects' earnings (which are perfectly collinear to their performance) turn out to be significantly lower under noise exposure ($p < 0.10$ in a two-sided Fligner-Policello Robust Rank Order Test, Fligner and Policello 1981). However, part of the difference can be attributed to a few subjects[12] who missed to enter and confirm the number of mistakes they had counted into their computer terminals before time ran out, thus earning zero money in the task.[13] Interestingly, these instances only occurred in the noise treatment, despite identical oral warnings prior to beginning the task as well as 60-100 seconds before time was up. If these subjects are excluded, the difference in performance between the treatment group and the control group is insignificant ($p = 0.57$). As mentioned before, both results, unaffected performance and decreased performance under noise, have been found for comparable tasks in the literature. At the same time, subjects report to experience the administered noise as bothersome and disruptive. In the ex post questionnaire, a majority of treated subjects (61%) chooses one of the upper three categories on a scale of six answer possibilities to describe their feelings about the noise during the proofreading task. The six answer categories were presented as ranging from "not bothersome at all" to "extremely bothersome". Both results together would suggest the presence of an effort-by-stress trade-off among those subjects who are unaffected in performance (i.e. do not miss the timeout) and rate the noise as bothersome, thus the literature would suggest elevated levels of physiological stress among these subjects to prevent performance losses

[12] 8 out of 112.

[13] The upper right corner of the computer screen displayed a count down for the 25 minutes (in seconds).

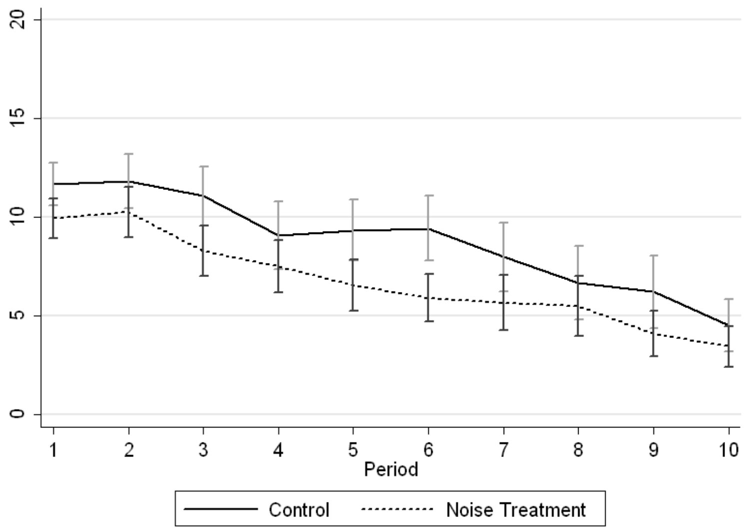

Figure 1: Mean contributions (in experimental points) of subjects in the control group and the treatment group. Error bars denote standard errors which are clustered at experimental groups ($N = 28$).

under noise.

Result 1 *Subjects performance in the proofreading task is not significantly different under noise exposure. However, some treated subjects miss to pay sufficient attention to the time constraint under noise. The majority of treated subjects rates the noise as bothersome.*

Turning to the aftereffect of noise in the public good game, Figure 1 depicts mean contributions for the control group and the treatment group. Clearly, average contributions of those exposed to noise prior to the game seem to be consistently below those of unexposed subjects. The effect is almost never significant, however, using two-sided tests, as Table 2 shows. Plausibly, the number of independent observations (28 experimental groups) is too small to identify a roundwise effect. Pooling group means of all periods would lead to highly significant two-sided test results ($p < 0.002$).

Result 2 *There is tentative nonparametric evidence that public good contribution levels in the noise treatment are consistently below those in the control treatment.*

Table 2: Significance of the treatment effect

		Period				
		1	2	3	4	5
Mean contri-	Noise	9.94	10.26	8.28	7.50	6.55
		(1.00)	(1.28)	(1.27)	(1.34)	(1.32)
bution (points)	Control	11.67	11.83	11.06	9.08	9.33
		(1.08)	(1.38)	(1.51)	(1.73)	(1.56)
Two-sided (one-sided) Fligner-Policello test		Ù=1.364 (*)	Ù=0.875	Ù=1.448 (*)	Ù=0.657	Ù=1.519 (*)
		Period				
		6	7	8	9	10
Mean contri-	Noise	5.89	5.65	5.48	5.48	3.44
		(1.20)	(1.41)	(1.51)	(1.16)	(1.03)
bution (points)	Control	9.44	7.98	6.67	6.21	4.52
		(1.67)	(1.73)	(1.86)	(1.83)	(1.32)
Two-sided (one-sided) Fligner-Policello test		Ù=2.006** (***)	Ù=1.229	Ù=0.708	Ù=0.812	Ù=0.774

Notes: Mean contribution is the average of the means of the experimental public good groups. Standard errors in parentheses are clustered at the group level. For periods 2-10, the Fligner-Policello tests the equality of the distributions of the group means. For period 1, the Fligner-Policello tests the equality of the distributions of the individual contributions. Stars indicate significance levels (* 10%, ** 5%, *** 1%).

3.2 Regression results

In order to exploit the controls obtained by the questionnaire, and in order to control for the unequal distributions between the treatment and the control group found for some demographics, this section presents regression results. Table 3 reports summary statistics for variables elicited in the questionnaire. The first three variables will be assumed to proxy for physiological stress, either acute (if subjects rate their day before the experiment as stressful or if they rate their effort in the proofreading task as high inducing an effort-by-stress tradeoff) or chronic (as measured by the 4-item PSS). The next three variables represent subjects' self-rated history of noise exposure on the experimental day prior to the experiment, over the past year, and during childhood at the place they lived most of the time. All but the PSS scale are dummy variables which are constructed from subjects' answers on a 6-item rating scale. The second set of variables are demographic characteristics.

Testing for systematic differences in the distributions of the answer ratings between

Table 3: Summary statistics of questionnaire variables

Variable	Mean	SD	Min	Max
Pre-experimental stress	.5714	.4971	0	1
Effort in part I	.6696	.4725	0	1
Chronic stress (4-item PSS)	6.009	3.036	0	15
Pre-experimental noise exposure	.6429	.4813	0	1
Chronic noise exposure (past year)	.4911	.5022	0	1
Noise exposure in childhood	.5446	.5002	0	1
Female	.5625	.4983	0	1
Age	22.13	2.625	18	33
Major belongs to the social sciences	.5	.5022	0	1
Pursues Bachelor's degree	.5893	.4942	0	1
Pursues Master's degree	.1339	.3421	0	1
Pursues Staatsexamen	.2321	.4241	0	1
Pursues other degree / no answer	.0446	.2074	0	1

the treatment group and the control group yields some evidence for endogeneity of the questionnaire responses. While for most variables, significant differences cannot be established (using a two-sided Fligner-Policello test), for the two questions on noise exposure during the past year and during childhood, subjects in the noise treatment report significantly lower exposures compared to the control group. The potential presence of a bias from endogeneity needs to be taken into account when interpreting regression results.

The econometric specification used in the regressions is

$$\begin{aligned} C_{i,t} = \quad & \beta_0 + \beta_1 P_{i,t} + \beta_2 T_{i,t} + \beta_3 S_{i,t} + \delta_1 (T_{i,t} \times S_{i,t}) \\ & + \beta_4 H_{i,t} + \delta_1 (T_{i,t} \times H_{i,t}) + \beta_5 D_{i,t} + \delta_1 (T_{i,t} \times D_{i,t}) \\ & + \beta_6 \textstyle\sum_{-i,t-1} C_{-i,t-1} + \beta_7 C_{i,t-1} \end{aligned}$$

where $C_{i,t}$ denotes subject i's contributions in period t, $P_{i,t}$ denotes a vector of dummy variables for the experimental periods, $T_{i,t}$ is the dummy indicating the treatment, $S_{i,t}$ and $H_{i,t}$ are the vectors of stress-related and noise-related controls as described above, $D_{i,t}$ is the vector of demographic controls, and the last two terms represent others' and i's own contributions to the group account in the previous period.

Table 4 reports coefficient estimates from OLS regressions.[14,15] The first specifica-

[14]Running random effects GLS panel regressions with period as the time variable yields very similar results with the same significance levels for all variables.

[15]Note that due to the small sample size, Table 4 also marks significance levels of below 20% (with

tion only includes the treatment variable, besides the period dummies. Columns (2) to (4) each include, in addition, one of the vectors containing variables related to either stress, noise history, or demographics as well as their interactions with the treatment variable.[16] Column (5) presents the full model. Column (6) corresponds to column (5), but, in addition, includes the experimental feedback variables for the previous period. Coefficient estimates for the period dummies and the constant, which are not reported in Table 4 but included in each specification, confirm a highly significant negative time trend, as suggested by Figure 1.

Column (1) confirms the insignificant negative treatment effect suggested by the nonparametric tests in Section 3.1. Controlling for self-reported variables related to stress in column (2), the results show significantly higher contributions among those subjects who both report a stressful day and were exposed to the noise. The limited statistical power of the sample prevents to clearly disentangle whether the interaction effect is due to a negative main effect of noise among the self-reported unstressed that is absent among the stressed, or whether the effect is due to a negative main effect of stress among the control group that is absent among the treated. Taking together the evidence from all specifications in Table 4 and from additional regressions, there is evidence for both. In an attempt to explain this finding, it appears that both a negative effect of noise as well as of stress is intuitive, but the significant absence of the negative effect if both conditions meet appears counterintuitive. In particular, the negative effect of pre-experimental stress would be consistent with “diminished coping from multiple stressors” (Evans and Cohen 2004) but this is inconsistent with un-diminished or even better coping under pre-experimental stress and noise. A potential explanation for this finding could be endogeneity of the questionnaire answers, however: If subjects felt tempted to ex post report a stressful day as an excuse for having given less, then the positive interaction effect would imply that in the noise treatment, subjects are simply less tempted to use this excuse and, at the same time, give less because of the noise exposure. Turning to the

one star in parentheses) for illustrative purposes, in order to point out variables that might plausibly qualify for significance in a larger sample.

[16] Among the demographic controls, I leave out age due to its small variation in the student sample. If there are effects, I expect them to be better reflected by the pursued academic degrees which plausibly proxy for maturity among students.

Table 4: OLS coefficient estimates of contributions to the group account

	(1)	(2)	(3)	(4)	(5)	(6)
Noise	-2.070	-3.784	-0.638	-5.199*	-5.919*	-2.316*
	(1.789)	(2.997)	(2.417)	(2.736)	(3.304)	(1.308)
Pre-exper. stress	–	-1.846(*)	–	–	-1.932(*)	-1.529***
		(1.238)			(1.429)	(0.551)
... * Noise	–	3.489*	–	–	2.917(*)	2.106***
		(1.771)			(2.150)	(0.704)
Effort in part I	–	2.719*	–	–	2.833(*)	0.728(*)
		(1.467)			(1.957)	(0.486)
... * Noise	–	-1.969	–	–	-1.608	-0.250
		(1.991)			(2.623)	(0.786)
Chronic stress (PSS)	–	-0.076	–	–	-0.088	0.000
		(0.218)			(0.283)	(0.110)
... * Noise	–	0.158	–	–	0.200	0.077
		(0.326)			(0.367)	(0.140)
Pre-exp. noise expos.	–	–	-1.527	–	-0.206	0.116
			(1.560)		(2.279)	(0.891)
... * Noise	–	–	1.765	–	0.961	-0.212
			(1.802)		(2.497)	(1.079)
Chronic noise expos.	–	–	3.397	–	3.236(*)	0.161
			(2.617)		(2.432)	(0.554)
... * Noise	–	–	-2.519	–	-0.773	0.783
			(2.783)		(2.762)	(0.705)
Noisy childhood	–	–	0.272	–	0.677	0.496
			(1.361)		(1.710)	(0.610)
... * Noise	–	–	-1.410	–	-1.455	-0.602
			(1.782)		(2.073)	(0.761)
Female	–	–	–	-0.906	-1.164	0.435
				(1.157)	(1.456)	(0.759)
... * Noise	–	–	–	0.449	-0.758	-0.368
				(1.543)	(2.179)	(0.891)
Major of the Soc. Sciences	–	–	–	-2.494(*)	-3.501*	-1.341(*)
				(1.858)	(1.844)	(0.817)
... * Noise	–	–	–	2.184	3.519(*)	1.437(*)
				(2.545)	(2.431)	(1.040)
Master student	–	–	–	-1.697	-2.918**	-0.961
				(1.822)	(1.383)	(0.916)
Staatsex. stud.	–	–	–	-3.384(*)	-3.526(*)	-1.094
				(2.510)	(2.372)	(0.858)
Other stud./n.a.	–	–	–	-0.906	-2.186	-0.850
				(1.743)	(1.774)	(1.313)
Master * Noise	–	–	–	-1.453	0.106	-0.004
				(2.193)	(2.216)	(1.019)
St.-ex. * Noise	–	–	–	6.916**	7.538**	1.520
				(3.112)	(2.920)	(1.167)
Other/n.a. * Noise	–	–	–	6.368**	9.664***	3.324**
				(2.405)	(2.888)	(1.577)
Others' contributions	–	–	–	–	–	0.138***
						(0.018)
Own contribution	–	–	–	–	–	0.465***
						(0.047)
N	1120	1120	1120	1120	1120	1008
# of clusters	28	28	28	28	28	28
R^2	0.113	0.140	0.134	0.171	0.227	0.597

Notes: (*) significant at the 20 % level, * at 10 %, ** at 5 %, *** at 1 %. Standard errors are clustered at the group level and shown in parentheses. All regressions include dummy controls for experimental periods and a constant. In columns (4)-(6), Bachelor students are the baseline.

effort in the proofreading task, there is no evidence that treated subjects reporting higher efforts behave different, potentially from an effort-by-stress tradeoff, as indicated by the insignificant interaction effect.[17] However, all subjects across treatments who report higher effort also tend to give more to the public good. This could be a manifestation of an experimenter demand effect. The measure of chronic stress, the PSS, does never significantly correlate with either contributions or noise. Altogether, the evidence on an effect of stress in the experiment is mixed and supports careful interpretation of simple ex post survey measures.

Result 3 *Survey measures of chronic stress insignificantly correlate with the both contributions to the public good as well as the effect of noise. Survey measures of acute pre-experimental or intra-experimental stress provide mixed evidence, and contamination of questionnaire answers by endogeneity, e.g. from ex-post rationalization or an experimenter demand effect, cannot be excluded.*

Column (3) reveals no significant main or interaction effects of the various types of self-reported noise exposure in the past. This points against a measurable presence of "adaptation level shifts" (Evans and Cohen 2004).

Result 4 *Regression results do not reveal any effects of the various types of self-reported past noise exposure on contributions or on the effect of noise on contributions.*

Employing demographic controls in column (4) delivers a significantly negative effect of the noise treatment for the baseline of Bachelor students. The effect persists for Master students, who do not significantly differ from the baseline, but is offset by a positive interaction effect of about the same magnitude for Staatsexamen students and for the residual category of other degrees and non-responding students. In addition, Staatsexamen students show tentative evidence for a negative main effect on contributions. As one would expect, there is (tentative) evidence that students with a major in the social sciences (mostly economics) give less. Male and female subjects do not significantly dif-

[17] In a future analysis of the data, a better way to test for a potential effect of an effort-by-stress tradeoff given the available variables would be to test of different behavior of subjects who (1) were in the treatment group, (2) reported over-average levels of effort, (3) reported the noise as bothersome, and (4) did not miss the timeout.

fer in giving behavior or reception of the treatment in the present sample, as one might have expected from findings by Epstein and Karlin (1975) for the effect of crowding.

Result 5 *Controlling for demographics, noise exposure significantly reduces contributions among subjects pursuing a Bachelor's or Master's degree, but not for other subjects in the sample. No such differences can be established between male and female subjects.*

All effects described above generally persist if we test the full model in column (5), with slight changes in the significance levels of some variables. Also, the full model adds (weak) evidence that the significantly negative effect of noise is less received by students of the social sciences, and that Master students give less in general. The latter effect can plausibly related to experience or age. The final column (6) conditions contribution choices on what happened in the previous period. Both experimental feedback variables are highly significant in explaining behavior in the current period. Including them affects significance levels of some variables, partly heavily, but does not alter coefficient signs.[18]

4 Conclusions

Despite a considerable body of literature in other disciplines, for example, environmental psychology, the effects of environmental stressors have not yet been in the focus of economists. And rightly so, if environmental stressors are, on aggregate, irrelevant to economic behavior and decision making. Environmental stressors pose an externality and source of market failure, however, if their effect is significant, if changes in their levels are permanent and man-made, and if adaptation is imperfect or costly. This paper provides evidence for the first of these three conditions. My results suggest a significant adverse effect of the exposure to acute ambient noise on the extent of voluntary giving to a linear laboratory public good.

Among the limited related literature, this result confirms findings of a negative effect of noise on helping behavior (Glass and Singer 1972, Sherrod and Downs 1974, Page 1977, Moser 1988). The finding supports altruism as the affected motivational transmitter, as

[18] Again, random effects GLS panel regressions with period as the time variable yield very similar results.

altruism is regarded a common motivation for both helping behavior and public good contributions (Andreoni 2006). In contrast, the result appears not in line with the hypothesis that physiological stress is the dominant physiological pathway of the noise effect, since the (sparse) literature suggests a positive effect of physiological stress on pro-social behavior (Dovidio and Morris 1975, von Dawans et al. 2012). However, it is beyond the scope of this paper to clearly identify the mediator causing the observed effect, and alternative hypotheses do exist. For example, risk preferences or cognitive processing capacities could equally plausible be the affected motivational drivers of public good giving if subjects perceive the group account as the more risky or more cognitively demanding option.[19] The same argument may hold for the effect on helping behavior reported in the literature. Likewise, alternative hypotheses besides physiological stress exist for the physiological transmission of the effect. For example, Page (1977) mentions stimulus overload, distraction, or escape and avoidance behavior as possible explanations for the negative effect on helping behavior. These could also be plausibly related to selfish behavior in cases of social dilemmas. Disentangling these various explanations for physiological or motivational causes of the effect is left for future research.

The effect of noise found in the present data is an effect of acute, short-term noise exposure. The extent to which the result may generalize to an environment of chronic noise exposure, such as urban areas or the vicinity to an airport, depends on adaptation, as mentioned before. Research on chronic effects naturally poses more difficulties as the researcher mostly relies on either empirical data or natural experiments. Regarding adaptation costs, the literature provides some evidence on the costs of adaptation to permanently increased noise levels. For example, chronic noise was found to adversely affect auditory discrimination in children and thus, reading acquisition, presumably due to a habituation of adaptation strategies to cope with chronic exposure (Cohen et al. 1973, Evans et al. 1995, Evans and Cohen 2004). If adaptation to chronically increased levels incurs significant costs, man-made changes in ambient levels of environmental stressors such as noise would be sources of relevant externalities in the economy, however.

[19]Not entirely related to this point, von Dawans et al. (2012) find unaltered propensities to take risks for higher levels of physiological stress.

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Appendix

Experimental instructions

[*Original wording. Translation to English available upon request from the author.*]

Willkommen zu diesem Experiment! Bitte **lesen Sie diese Anleitung sorgfältig** durch. Nur so wissen Sie, **wie Sie Ihren Verdienst durch Ihre Entscheidungen und Antworten beeinflussen**. Wenn Sie den Instruktionen folgen, können Sie insgesamt einen angemessenen Geldbetrag verdienen.

Dieses Experiment besteht aus **zwei Teilen** und einem abschließenden **Fragebogen**. Alle Teilnehmer nehmen am gleichen Experiment teil und lesen die gleiche Anleitung wie Sie.

Ab jetzt und bis zum Ende des Experiments ist es Ihnen **untersagt, mit anderen Teilnehmern zu kommunizieren**. Wenn Sie während des Experiments eine **Frage** haben, **heben Sie einfach die Hand**.

Alle Ihre Angaben werden **vertraulich** behandelt und sind **anonym**. Das einzige Mal, wo Ihr Namen und Ihre Adresse benötigt wird, ist auf der Empfangsbestätigung / Quittung der Auszahlung, die Sie **bitte jetzt ausfüllen**. Tragen Sie dort auch die Computernummer Ihres Sitzplatzes ein, damit Ihnen Ihr Verdienst nach dem Experiment zugeordnet werden kann. Das Feld für den **Betrag bitte freilassen**.

Um die **wissenschaftliche Verwertbarkeit** dieses Experiments zu fördern, treffen Sie alle Ihre Entscheidungen am besten frei von Mutmaßungen über den wissenschaftlichen Gegenstand dieses Experiments. Vielen Dank.

Auszahlungen

Während des Experiments spielen Sie um Punkte. Nach dem Experiment werden die Punkte, die Sie verdient haben, in Euro umgerechnet. Dabei entspricht **1 Punkt = 1,5 Eurocent (0,015 Euro)**. Zusätzlich zum variablen Verdienst erhalten Sie eine feste Teilnahmevergütung von 3,00 Euro.

Experiment Teil 1

Während des ersten Teils des Experiments lesen Sie mehrere Texte auf Papier. Jeder Text enthält **Rechtschreib- und Grammatikfehler**. Finden und zählen Sie die Fehler, und **tragen Sie die Anzahl in das entsprechende Feld auf dem Computerbildschirm ein**. Für jeden richtig erkannten Fehler erhalten Sie **5 Punkte**. übersteigt die Anzahl der Fehler, die Sie eintragen, die wahre Anzahl der Fehler im Text, werden Ihnen für jeden falsch erkannten Fehler wieder 5 Punkte abgezogen. Ihr Verdienst kann jedoch nicht negativ werden, sondern beträgt immer mindestens 0 Punkte.

Beispiel 1: Ein Text enthält 8 Fehler. Sie tragen 5 Fehler ein. Sie erhalten 25 Punkte.
Beispiel 2: Ein Text enthält 8 Fehler. Sie tragen 10 Fehler ein. Sie erhalten 30 Punkte.
Beispiel 3: Ein Text enthält 8 Fehler. Sie tragen 30 Fehler ein. Sie erhalten 0 Punkte.

[*Only the treatment group saw the following paragraph:*] Während dieses Teils des Experiments wird der Raum mit **Geräuschen** beschallt. Der Pegel der Geräusche ist dabei stets gesundheitlich unbedenklich und entspricht Pegeln, denen Sie auch im Alltag begegnen.

Experiment Teil 2

Der zweite Teil des Experiments besteht aus **10 Runden**. Zu Beginn des zweiten Teils werden Sie über Computer per Zufallsauswahl **mit drei anderen Teilnehmern/-innen** im Raum zu einer Gruppe zusammengeschaltet. **Keiner der Gruppenmitglieder kennt die Identität** der anderen Gruppenmitglieder; sie wird auch nach dem Experiment nicht offengelegt. **Ihr Verdienst** in diesem Teil wird sowohl durch Ihre **eigenen** Entscheidungen als auch durch die **Entscheidungen der anderen** Teilnehmer in Ihrer Gruppe beeinflusst.

In jeder Runde sind Sie und die anderen Mitglieder Ihrer Gruppe mit der gleichen Entscheidungssituation konfrontiert: Jede(r) bekommt **20 Punkte zur Verfügung** gestellt und entscheidet, wie sie oder er diese **auf zwei Alternativen verteilen** möchte. Die beiden Alternativen sind ein **privates Punktekonto** und ein **gemeinsames Konto Ihrer Gruppe**.

- **Privates Konto**: Jeder Punkt, den Sie Ihrem privaten Konto zuteilen, erhöht (ausschließlich) Ihren **eigenen** Punkteverdienst, und zwar **um 1 Punkt**.
- **Gruppenkonto**: Jeder Punkt, den Sie dem Gruppenkonto zuordnen, erhöht den Punkteverdienst **bei allen Mitgliedern der Gruppe**, inklusive Ihnen, und zwar **um 0,4 Punkte**. Gleiches gilt, wenn ein anderes Mitglied Ihrer Gruppe Punkte dem Gruppenkonto zuteilt: Jeder Punkt erhöht den Verdienst bei allen in der Gruppe um 0,4 Punkte.

Ihr persönlicher Verdienst pro Runde lässt sich nach diesen Regeln wie folgt zusammenfassen:

Ihr Verdienst pro Runde = Ihre Zuteilung zum privaten Konto + 0,4 x Summe der Beiträge aller Gruppenmitglieder zum Gruppenkonto

Bitte beachten Sie, dass Ihnen der Einfachheit halber auf dem Computerbildschirm nur **ein** Feld zum Eintragen von Punkten gezeigt wird. Dort tragen Sie ein, wie viele der 20 Punkte Sie dem **Gruppenkonto** zuweisen möchten. Alle übrigen Punkte, die Sie nicht dem Gruppenkonto zuteilen, werden dann automatisch dem privaten Konto zugeteilt.

Beispiel: Angenommen, Sie behalten 10 Punkte für das private Konto und tragen 10 Punkte in das Feld für das Gruppenkonto ein. Ferner sei angenommen, die anderen Gruppenmitglieder tragen ebenfalls zum Gruppenkonto bei. Nehmen wir an, insgesamt kommen auf dem Gruppenkonto 40 Punkte zusammen. Diese 40 Punkte bewirken eine Auszahlung von 0,4 x 40 = 16 Punkte für jeden in der Gruppe. Ihr eigener Verdienst beträgt also die 16 Punkte vom Gruppenkonto und die 10 Punkte auf Ihrem privaten Konto = 26 Punkte.

Die **Tabelle** auf Seite 3 gibt eine übersicht über Ihren Verdienst für einige beispielhafte Kombinationen wieder. Sie lesen die Tabelle wie folgt: **Zeilen** stehen für Beispiele, wie viele Punkte **Sie** dem Gruppenkonto zuteilen (also zwischen 0 und 20). **Spalten** stehen für Beispiele, wie viele Punkte die **anderen drei Gruppenmitglieder insgesamt** auf das Gruppenkonto einzahlen (also zwischen 0 und 60). Jede **Zelle** gibt Ihren persönlichen **Rundenverdienst** wieder, der sich wie oben beschrieben berechnet. Bitte vergewissern Sie sich jetzt, dass Sie die Tabelle vollständig verstehen. Zögern Sie nicht, die Hand zu heben, wenn Sie eine Frage haben.

Vor jeder neuen Runde werden Ihnen Informationen über die vergangene Runde angezeigt, und zwar über:

- Ihren **eigenen Beitrag** zum Gruppenkonto, den Sie in das Feld auf dem Bildschirm eingegeben haben,
- die **Summe der Punkte aller vier Gruppenmitglieder auf dem Gruppenkonto**,
- Ihren **Verdienst** in der vergangenen Runde, der sich aus diesen Entscheidungen ergibt.

Fragebogen

Das Experiment endet mit einem Fragebogen, währenddessen Ihre Auszahlung vorbereitet wird. Die Antworten auf Fragen im Fragebogen geben Sie am besten spontan, ohne lange und wiederholt darüber nachzudenken.

Danke für Ihre Teilnahme!

Tabelle: Ihr Verdienst einer Runde in Teil 2, für beispielhafte Kombinationen

Ihr Beitrag zum Gruppenkonto	Gesamter Beitrag der anderen drei Gruppenmitglieder zum Gruppenkonto								
	0	**3**	**6**	**15**	**30**	**45**	**54**	**57**	**60**
	Ihr Verdienst:								
0	20	21,2	22,4	26	32	38	41,6	42,8	44
1	19,4	20,6	21,8	25,4	31,4	37,4	41	42,2	43,4
2	18,8	20	21,2	24,8	30,8	36,8	40,4	41,6	42,8
5	17	18,2	19,4	23	29	35	38,6	39,8	41
10	14	15,2	16,4	20	26	32	35,6	36,8	38
15	11	12,2	13,4	17	23	29	32,6	33,8	35
18	9,2	10,4	11,6	15,2	21,2	27,2	30,8	32	33,2
19	8,6	9,8	11	14,6	20,6	26,6	30,2	31,4	32,6
20	8	9,2	10,4	14	20	26	29,6	30,8	32