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ABHANDLUNGEN

Road Traffic and Aircraft Noise as Drivers of Environmental Protest?

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Abstract This article investigates whether and to what extent unfavorable local environmental conditions furnish an important motivator for environmental protest. We do so using individual-level data on objective and subjectively perceived residential road traffic and aircraft noise pollution, pertaining to the cities of Mainz (Germany) and Zurich (Switzerland). By referring to fine-grained noise data, we are able to test the predictive power of grievances and self-interest in explaining protest participation more stringently than has been the case in most previous studies. Theoretically, our study is inspired by Klandermans' socio-psychological framework of political protest, the pressure-response approach, the self-interest perspective, and the collective-interest model. Our empirical findings only partially confirm the grievances assumption that unfavorable local environmental conditions in the form of residential road traffic and aircraft noise stimulate environmental protest. Noise caused by airplanes seems to be more "protest-inducing" than that produced by road traffic. It is not so much the objectively measurable noise level as its subjective perception and evaluation that are deciding factors. However, in line with Klandermans' protest framework and other theories of political protest, there are more influential drivers of environmental protest, such as environmental concerns and a left-wing political ideology. Thus, the effects of residential road traffic and aircraft noise turn out to be

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relatively moderate. Ultimately, this means that our tailored measures of grievances corroborate a relatively well-established finding of protest research.

Keywords Noise pollution · Environmental risks · Environmental activism · Political protest · Theories of political protest

Straßen- und Flugverkehrslärm als Triebfedern von Umweltprotesten?

Zusammenfassung Der Beitrag geht der Frage nach, ob und inwieweit lokale Umweltbelastungen eine wichtige Triebfeder für Umweltproteste darstellen. Dabei werden Individualdaten zu objektivem und subjektiv wahrgenommenem Straßen- und Flugverkehrslärm im Wohnumfeld verwendet, die in Mainz (Deutschland) und Zürich (Schweiz) erhoben wurden. Der Rückgriff auf vergleichsweise präzise Lärmdaten eröffnet die Möglichkeit, die Rolle von Problemdruck und Eigeninteresse bei der Vorhersage der Beteiligung an politischem Protest stringenter zu untersuchen als in den meisten bisher vorliegenden Studien. Als theoretischer Hintergrund fungieren Klandermans' sozialpsychologischer Bezugsrahmen politischen Protests, der Pressure-response-Ansatz, die Perspektive des Eigeninteresses und das Collective-interest-Modell. Die empirischen Ergebnisse bestätigen nur teilweise die Problemdruckannahme, dass lokale Umweltbelastungen in Form von Straßen- und Flugverkehrslärm die Wahrscheinlichkeit einer Beteiligung an Umweltprotesten erhöhen. Fluglärm erscheint stärker „protestaffin" als Straßenverkehrslärm. Weniger der objektive Lärm, sondern eher dessen subjektive Wahrnehmung und Bewertung sind ausschlaggebend. Unabhängig davon und in Übereinstimmung mit Klandermans' Bezugsrahmen sowie anderen Protesttheorien sind die Effekte von Straßen- und Flugverkehrslärm auf die Protestbeteiligung moderat und deutlich schwächer ausgeprägt als die Effekte individueller Prädispositionen wie Umweltbewusstsein und politische Links/Rechts-Orientierung. Dies bedeutet, dass auch auf der Grundlage unserer sehr gezielten Messungen des individuellen Problemdrucks ein bekanntes Ergebnis der politischen Protestforschung bekräftigt wird.

Schlüsselwörter Lärmbelastung · Umweltrisiken · Umweltaktivismus · Politischer Protest · Theorien politischen Protests

1 Introduction

Although local environmental conditions have improved in many OECD countries over the last 50 years, the progress made so far still leaves room for improvement, as it has been of limited scope, counteracted by opposing developments, and is far from sustainable (OECD 1991, 2008, 2012). Concurrently, there seems to be a broad societal consensus that additional political and individual interventions are imperative if environmental protection is to be strengthened. Given these circumstances, civic environmental activism and public political protest may help to initiate and advance the structural changes required to approach sustainable development.

Some observers, e.g., in the tradition of the OECD pressure-state-response model (OECD 2003, p. 21), expect that the requisite action, including political protest, will arise more or less automatically when societies are confronted with stronger environmental pressures, whether on the local, national, or global level. But a considerable body of theoretical and empirical protest research remains highly skeptical of the proposition that unfavorable or deteriorating conditions stimulate protest (for more, see Sect. 2). It is argued that the effects of pressures, grievances, and self-interest on protest participation are limited, if not non-existent.

However, one reason for inconclusive findings may be that in many previous studies the conceptualization and measurement of grievances has been poor and/or not fit for purpose. Therefore, it is the main purpose of this paper to contribute to the "grievances debate" by empirically testing the predictive power of more precise, fine-grained, and specific measures of grievance.

With regard to potential motivators for environmental protest, the article does not consider national or global environmental threats, but rather concentrates on local risks. Local problems are part of everyday life, can be experienced on a daily basis, and may drastically reduce individual quality of life. In contrast, people do not necessarily experience national or global environmental threats themselves. Individual perceptions of them are strongly influenced by public debate on environmental issues, agenda-setting processes in the media, and personal information-seeking strategies. Hence, national or global threats are less suitable for investigating the link between exposure to environmental risks and political activism. If there is such a link, it should be most clearly demonstrable at the level of local threats.

We shall focus on residential road traffic and aircraft noise as prominent examples of local environmental "bads." It is well known from numerous studies, mainly stemming from the field of noise and sound research (for overviews, Hellbrück et al. 2008; Murphy and King 2014; Cowan 2016), that residential noise pollution is a stress factor that reduces subjective well-being and endangers individual health. Furthermore, residential noise is often connected with other local threats such as air pollution or a lack of recreational green spaces. Compared with air pollution, exposure to noise is perceived more directly and easily, and is, thus, better suited for addressing our research question.

To investigate the link between exposure to traffic/aircraft noise and environmental protest, the article draws on empirical data from two cities: Mainz in Germany and Zurich in Switzerland. An innovative aspect is that our study includes not only survey data pertaining to subjectively perceived environmental annoyances and potential reactions, but also objectively measured local environmental conditions, that is, actual exposure to road traffic and aircraft noise. This enables us to examine the relationship between objective and subjectively perceived noise and to explore their combined effects on protest activities. Within environmental research and policymaking, the need for a joint evaluation of both objective and subjective noise variables has been emphasized repeatedly (e.g., Verbeek 2018, p. 448).

The article begins by outlining the theoretical and empirical background that inspired and guided our research (Sect. 2). Next, there follows a depiction of the data and variables (Sect. 3). The empirical results are presented in two steps: Step one is devoted mainly to descriptive findings; step two presents findings from multiple

regression models (Sect. 4). The latter models take determinants of environmental protest into account, with a special focus on the role and effects of objective and subjective residential noise parameters. The article concludes with remarks on the more general relevance of the research topic, a summary of our findings, and potential limitations of the study (Sect. 5).

2 Theoretical and Empirical Background

Seeking to explain citizens' participation in protest activities, including environmental protest, is an important research field within the political and social sciences, and there has been a great deal of both theoretical and empirical research on this topic. Focusing upon our research question of whether exposure to local environmental risks stimulates protest activities, we shall first briefly review empirical findings and prominent protest theories, aiming to explain the protest participation of individual actors. This review and supplementary considerations regarding our specific study will lead us to a set of expectations and hypotheses to be tested in the empirical analyses.

2.1 Exposure to Residential Environmental Threats and Research on Political Protest

Ample research on political protest (for overviews, see Klandermans 2004; Opp 2009; Quaranta 2017; Van Stekelenburg and Klandermans 2017) informs us that individual participation in protest activities depends on a wide range of influences—local grievances and disamenities being just one of many potentially significant factors. In what follows, we will first map out this range of influences by referring to Klandermans' protest framework, then we will zoom in on our topic—the "grievances component."

2.1.1 Klandermans' Socio-psychological Framework

In a review of theoretical and empirical research on protest and social movements, Klandermans (2004) develops a socio-psychological framework of participation in protest activities. Therein, he distinguishes between supply- and demand-side influences on protest participation. The supply factors refer to existing social and political opportunities for protest. If, for instance, an infrastructure of protest groups already exists, it is easier for individual actors to convert dissatisfaction into actual protest behavior. On the demand side, Klandermans identifies three fundamental motives that "account for most of the demand for collective action in a society" (p. 361): (1) "ideology," i.e., people may want to express and affirm their political convictions; (2) "identity," i.e., they may want to act as members of their group; and (3) "instrumentality," i.e., they may want to change their circumstances. The ideology component pertains mainly to general values and basic political orientations. A prominent example of value orientations is Inglehart's (1977) postmaterialism and—in the context of environmental protection—general environmental concern

as a facet of postmaterialism. The most famous political ideology concept is the traditional left- versus right-wing political orientation. The identity factor primarily comprises group identification and local identification. Individual protest behavior is often embedded in peer group contexts, support and approval from peers being well-established as motivation factors for participation in protest activities. Our research topic, poor local environmental conditions, can be subsumed under Klandermans' third factor, the instrumentality component. The literature offers at least three, more specific theoretical models explicitly focusing on this aspect: the pressure-response model, the self-interest model, and the collective-interest model. Although these three models clearly overlap, we will discuss them separately in conjunction with empirical findings concerning grievances explicitly pertaining to the environment quality.

2.1.2 Pressure-Response Model

The most fundamental idea for explaining political protest is a simple pressure-response model. In its basic version, e.g., in the form of the pressure-state-response model of the OECD (2003), pressures such as unhealthy environmental conditions are diagnosed and measured in objective terms (bad air quality, high noise levels, etc.), the assumption being that they will ultimately be evaluated negatively, leading people to react with the aim of improving the situation. The set of people arriving at negative evaluations and initiating corrective action may not only consist of those directly affected by the unfavorable conditions but may also include outsiders guided by other reasons for their engagement (e.g., responsive politicians, representatives of NGOs, or politically engaged citizens). Pressure-response models starting at the level of subjective perceptions and evaluations most often run under the heading "grievances and relative deprivation theory" (for a classical contribution, see Gurr 1970). Negative evaluations of environmental circumstances, especially an unfair distribution of environmental risks, lead to discontent and frustration, which in turn—according to the frustration-aggression mechanism—spur political protest. Many studies in the field of "environmental justice" (see Mohai et al. 2009; Walker 2012; Preisendörfer 2014) follow this general idea.

However, there are serious objections to the pressure-response model. The objective version of the model overlooks the complications of the relationship between "objective risks" and societal and individual definitions of "problems" or "grievances." Ample research has demonstrated the importance of the framing and social construction of environmental problems, detailing how these vary between societies and cultural settings and change over time (see Douglas and Wildavsky 1983). Although millions of people in today's world evidently live under terrible environmental conditions, they personally articulate and prioritize problems other than environmental risks. Indeed, there is one group of protest and social movement theories following a framing perspective (for the basics, see Snow et al. 1986; see also Opp 2009, Chapter 8) and, thus, focusing explicitly on such processes of the social construction, political framing, and agenda setting of problems and grievances. Furthermore, even if a subjective version of the pressure-response model is adopted, that is, if the theory sets dissatisfaction and frustration as its starting points, there

remains a loose connection between subjective perceptions and evaluations on the one hand and actual protest participation on the other. Discontent with regard to residential noise may simply lead to "exit" decisions (Hirschman 1970), that is, moving out of the residential area; or it may lead to people taking measures to shelter their homes and apartments (noise insulation, etc.); or they may try to adapt, suffer "in silence," so to speak, and concern themselves with coping with the resulting problems. In line with these objections, summaries of empirical findings report inconsistent results and only sometimes find significant direct or indirect effects of grievances on political protest (Opp 2000, 2009, pp. 129–131; Quaranta 2017, Chapter 3.3). Nonetheless, our research is founded on the assumption that at least some of these inconsistencies result from poor measurements of objective and subjective environmental hardships.

2.1.3 Self-Interest Model

A theory more specific than the pressure-response model is the self-interest model, which also often runs under the contested heading "NIMBY model" (not in my backyard, e.g., Rohrschneider 1988; Van der Horst 2007; Devine-Wright 2009, 2013; Johnson and Scicchitano 2012).[1] Assuming selfish actors, calculating the costs and benefits of their behavior, the self-interest model of political protest postulates that people will engage only, or at least primarily, when an issue impinges directly on their personal life circumstances. Unfavorable environmental conditions (such as residential road or aircraft noise) clearly belong to the issues threatening individual quality of life. The self-interest perspective conveys the basic idea that people predominantly care about themselves. Consequently, they will become active and get involved only if external events endanger their personal well-being. There are many everyday examples illustrating the application of the common-sense self-interest principle (Lober 1995; Johnson and Scicchitano 2012; Ahlfeldt and Maennig 2015). However, the question is whether this principle holds as a general empirical regularity.

Empirical studies specifically looking at local environmental risks usually find that the self-interest model only has moderate explanatory power (e.g., Baldassare and Katz 1992; Pelletier et al. 1996; Nevitte and Kanji 1997; Séguin et al. 1998; Lubell et al. 2006; Preisendörfer 2017). In an older field study, investigating protests against the extension of a rapid railway route in Mannheim (Germany), Prester et al. (1987) empirically validate the causal chain "personal exposure to environmental threats → negative evaluation of them → participation in protest activities."

[1] It seems problematic to use the terms self-interest and NIMBY model synonymously. NIMBY usually describes a special self-interest constellation resting on two assumptions: First, it assumes a situation that certain infrastructure facilities are essential for the functioning of a society and should be provided in any case. Second, NIMBY presupposes a generally favorable attitude toward a certain object in combination with its rejection in its own neighborhood. Both assumptions are critical (and probably invalid) in our case, the provision of road traffic and aircraft facilities. Furthermore, based on the two assumptions, the NIMBY terminology often comes with a normative bias, it tends to discredit protests as selfish, particularistic, and ultimately unjustified (with respect to wind power and renewable energy, for instance, see Wolsink 2000, 2007; Van der Horst 2007). We therefore abstain from using the NIMBY terminology.

Notably, it was not the exposure itself, but rather "evaluations of environmental stressors [that] turned out to be substantial predictors of participation" (p. 782). Based on statistical data and a survey conducted in British Columbia (Canada), Blake (2001) arrives at inconclusive results. On the one hand, "there is clear evidence that objective environmental conditions of a particular kind serve to stimulate direct political action by individuals and groups" (p. 717); on the other, unfavorable environmental conditions seem to reduce attitudinal support for collective environmental action (such as tougher anti-pollution laws). Reconciling these two findings is no easy task. Ecological fallacies potentially resulting from his aggregate data on objective environmental conditions may have distorted Blake's findings. Similarly, based on a Canadian survey, Wakefield et al. (2006) find that perceived exposure to local environmental threats, as specified by feeling annoyed by the air pollution in one's neighborhood, positively affected the probability that respondents would contact government or industry organizations or attend public meetings regarding environmental issues. However, increased annoyance did not significantly influence participation in environmental protest rallies.

2.1.4 Collective-Interest Model

Probably the most elaborate theory for explaining individual participation in political protest is the collective-interest model, originally developed by Finkel et al. (1989; for further details, see Opp 2009, pp. 108–118). This model is rooted in the tradition of rational choice theory and, thus, shares similarities with the self-interest model. As an important refinement, however, it takes both the public good character of the state of environment and the collective action problem of environmental protest into account. The public good character means that those who do not contribute to the good (here: improvement of the local environment) will also benefit from it, because it is not possible and/or feasible to exclude them from the consumption of the good when it is provided. The collective action problem implies that there is an incentive for individual free-riding behavior. Strictly rational actors will not participate in protest, but follow the logic of free riding. However, the collective-interest model suggests a more moderate version of the rational actor by favoring a broader conception of rational behavior. According to this model, the expected value of participation in political protest—as calculated by an individual actor *i*—depends on five factors:

1. *i*'s perceived value of the collective good,
2. *i*'s perceived probability that the protest as a whole will be successful,
3. *i*'s perceived probability that success depends on his or her participation,
4. *i*'s selective costs for participation,
5. *i*'s selective benefits from participation.

Lubell (2002) and Lubell et al. (2006) present two applications of this model to the case of environmental activism and protest. Although local environmental risks are not a direct element of the model, the authors argue that unfavorable local conditions are relevant because they increase the perceived value of the collective good, that is, factor (1) of the above determinants of protest participation. Indeed, in

both studies, the authors report significant effects of perceived environmental threats on environmental activism. However, we should exercise caution when examining the measurement of "perceived environmental threats." In the first study (Lubell 2002), these measurements were based on relatively broad survey questions such as: "In general, do you think air pollution by cars (nuclear power, water pollution...) is dangerous for you and your family?" In the second study (Lubell et al. 2006), which focused on air pollution activism in Texas, measurements were based on "perceptions of local risk from air pollution to human health, natural resources, economic activity, and overall community image" (p. 153). Such operationalizations do not capture the concept of personal exposure to local environmental threats directly. Lubell et al. (2006) concede that their local risk measures should be supported by objective data on environmental quality. In fact, they matched some objective measures of air quality at the level of ZIP codes to their survey data. However, ZIP code regions in the USA are probably too large to offer grounds for appropriate analyses.

In sum, empirical research on the protest effects of local environmental threats currently exhibits shortcomings: Most studies do not include measures on objective conditions but rely exclusively on survey data and, thus, on subjective measures. If objective measures are taken into account, they often capture environmental conditions at an aggregate level (neighborhood, city district, ZIP code, etc.). This level problem also often pertains to subjective measures in the sense that the grievances being inquired in the surveys vary in their local radius. The measures of local pressures and grievances that we will use incorporate both objective and subjective measures and are focused on the subjects' immediate place of residence.

2.2 Further Theoretical Considerations and Hypotheses

The previous section makes the general point that it is essential to differentiate between objective local environmental conditions and their subjective perception and evaluation. With regard to their relationship, it can be expected that objective conditions will strongly influence subjective perceptions and evaluations. Numerous studies in noise research (e.g., Marquis-Favre et al. 2005; Hellbrück et al. 2008) have found that the objective noise level is the most important predictor of the subjectively perceived level. Nevertheless, objective noise conditions will surely not deliver "the whole story" when we seek to explain subjectively perceived and evaluated noise conditions (Guski 1999; Klaeboe et al. 2004; Miedema 2007).

We begin with the hypothesis that personal exposure to unfavorable conditions in the form of residential road traffic and aircraft noise pollution stimulates political protest activities. We expect that the direction of influence follows an "exposure–dissatisfaction–opposition" path, as suggested by the pressure-response model. In our context, this means that empirical models that take only objective noise parameters into account should show a significant effect on protest. Further, it means that models including only subjectively perceived and evaluated noise variables should reveal stronger effects than the objective variables. And, finally, it means that the effect of objective noise should lose significance when both objective and subjective noise measures are included in the model equations, as subjective noise perceptions and evaluations act as a mediator of objective noise.

A relatively specific variable inspired by the self-interest model is homeownership. According to the "homevoter hypothesis" (Fischel 2001), homeowners will engage in stronger resistance to environmental "bads" in their neighborhood than apartment or house renters. Whereas renters tend to be compensated for environmental disamenities such as residential noise by lower rental charges, homeowners are laden with a double burden: they are not only exposed to the environmental risks but also fall victim to a potential concurrent decline in the value of their real estate. Ahlfeldt and Maennig (2015) review previous research on the homevoter hypothesis and test it empirically for airports in the metropolitan area of Berlin. They find that homeowners had a significantly stronger tendency not only to oppose additional aircraft noise but also to support its reduction. Therefore, our hypothesis is that homeowners—compared with renters—will have a stronger tendency to participate in protest activities against road traffic and aircraft noise in their neighborhood.

Concerning the question of whether road traffic or aircraft noise will have a stronger effect on protest participation, we expect a stronger influence of aircraft noise for the following reasons. If present, aircraft noise can reach higher peak noise levels than road traffic. It is, therefore, more difficult to undertake individual measures to reduce or eliminate aircraft noise in one's own residential surroundings. Furthermore, road traffic, and especially road traffic relying on privately owned cars, is highly decentralized, with many actors producing potentially annoying noise. This makes it difficult to attribute responsibility. Aircraft traffic, however, is more centralized; it can be planned and influenced by a small group of actors (airport companies, airlines, local politicians). Hence, political protest against aircraft noise can target a specific group of actors who actually have the power to make a change to the current situation. Viewed through the lens of the collective-interest model, the perceived probability of success should, thus, be higher than in the case of road traffic noise.

As already mentioned in the introduction (Sect. 1), our study pertains to two cities, Mainz in Germany and Zurich in Switzerland. Mainz, with 210,000 inhabitants, is located in the larger Frankfurt metropolitan area, and—within the German context—can be qualified as a relatively affluent city. Zurich with 400,000 inhabitants is the largest city in Switzerland, and also one of the richest Swiss municipalities. In advance, we do not have any conclusive arguments for the expectation that the suggested effects of road traffic noise on protest will differ between Mainz and Zurich. With respect to aircraft noise, however, there is some reason to expect more pronounced effects in Mainz. Both cities are located near airports. Mainz is affected by Frankfurt Airport, which is about 25 km east of the city, and Zurich by Zurich Kloten Airport, which is about 10 km north of the city. In both cities, aircraft noise and aviation facilities have been a highly controversial public issue for many years (for Mainz, see, e.g., Schreckenberg et al. 2010; Wiebusch 2014; for Zurich, e.g., Wirth 2004), and this was one of the reasons why we selected these two cities for our study. In Mainz, however, based on a recent airport expansion, the aircraft noise issue was more acute within the timeframe of 2010 to 2015—the years directly preceding our period of observation—than in Zurich. In October 2011, Frankfurt Airport opened a new runway, accompanied by a great deal of protest from individual citizens, environmental groups and local community authorities (the city council

of Mainz included). Although a night flight ban between 11 p.m. and 5 a.m. was enacted during the negotiation process for the new runway, there are still regular protest demonstrations, and the airport company is in a more or less permanent clinch with neighboring communities and environmental action groups. This means that those bothered by aircraft noise in Mainz have viable opportunities for protest on offer. They can refer to an established protest infrastructure that enables and stimulates protest participation. Although such an infrastructure also exists in Zurich, its ongoing organizational basis is weaker because there are fewer current mobilization events. In this sense, Klandermans' supply-side factors of protest participation are more favorable in Mainz than in Zurich and, following the collective-interest model, the selective costs of protest participation are relatively lower in Mainz.

Of course, also in line with Klandermans (and other protest theories), we should be aware that in addition to grievances and self-interest, there are other important determinants of participation in environmental protest. These influences will have to be taken into account as control variables. Indeed, based on the results from previous studies, we expect some of these other determinants to be more powerful predictors than the local noise parameters in which we are primarily interested. Besides sociodemographic attributes, represented by "gender" and "age," our multiple regression models will take "education" and "social status" into account. People with higher educational achievement and higher social status have more resources and more capabilities with which to convert grievances and dissatisfaction into public protest, and therefore—according to the resource mobilization theory of political protest (see Opp 2009, Chapter 5)—we expect that they will engage more often in environmental protest activities. Focusing on Klandermans' ideology factor (Sect. 2.1), our models will incorporate "environmental concern" as a general attitude and "right/left-wing political orientation" as a political worldview variable. The assumption is that subjects with a higher level of environmental concern and with a left-wing political orientation will exhibit more frequent protest participation. With respect to Klandermans' identity factor and to Hirschman's (1970) exit, voice, loyalty (EVL) theory, we shall include "city attachment" as a potential predictor of protest. The hypothesis is that citizens articulating a stronger identification with their city of residence will engage in protest more often should their residential area be affected by noise pollution. Further variables taken into account pertain to the information on whether the subjects are "motor car users" and "aircraft users." Those who drive their own car and/or fly in aircraft fairly regularly bear a certain responsibility for road traffic and aircraft noise, and this should reduce their personal inclination to participate in protest against these disamenities. Finally, inspired by studies in the field of noise research, we shall include "noise sensitivity" as a covariate. Noise sensitivity is an established variable in noise research; it is an important direct predictor of subjective noise annoyance and a mediator in the transformation of objective noise exposure into subjective noise annoyance (e.g., Miedema and Vos 2003; Van Kamp et al. 2004; Klaeboe et al. 2004). We expect stronger individual noise sensitivity to stimulate participation in protest activities.

3 Data and Variables

After first introducing the empirical data, this section will depict the variables used in the analyses and their operationalization.

3.1 Empirical Data

The main empirical data for the following analyses come from surveys in the city of Mainz (Germany) and the city of Zurich (Switzerland). Data were gathered in a joint project supported by the German Research Foundation (DFG) and the Swiss National Science Foundation (SNSF). The title of this project was "Environmental Justice—Social Distribution, Justice Evaluations, and Acceptance Levels of Unfavorable Local Environmental Conditions." Other than some local adaptations, the surveys in the two cities were strictly comparable in terms of both research design (sampling procedure, etc.) and question program. The surveys were carried out as mail questionnaires and were conducted between October 2016 and March 2017 (for methodological details, see Bruderer Enzler et al. 2019).

The surveys were based on random samples of the adult population (18–70 years old) in Mainz and Zurich. The addresses of the random samples came from the official population registers managed and maintained by the city administrations (Einwohnermeldeamt in Mainz, Einwohnerregister in Zurich). The samples included not only people of German or Swiss nationality but also foreigners living in the cities. Because we had the exact address of our respondents, we were additionally able to locate the spatial coordinates of their places of residence using a geographic information system (GIS). The GIS coordinates enabled us to match objective noise data to the survey data (see Sect. 3.2).

Subjects selected for participation in the study were approached following Dillman's (2007) tailored design method; that is, they received a first invitation to participate in the survey (cover letter and questionnaire), a postcard after one week, a second invitation after three weeks (cover letter and questionnaire), and a third invitation after seven weeks (again, cover letter and questionnaire).[2] Field work was organized by the University of Mainz and the ETH Zurich, which the respondents could clearly recognize via the cover letter and the questionnaire. It is important to note that the surveys were not introduced as an environmental survey, but as a survey entitled "Housing and Living in the City of [Mainz/Zurich]."

In Mainz, the mail survey started with 4000 addresses, leading ultimately to 1800 completed questionnaires. Ignoring diverse causes for nonresponse, the raw response rate is 45%. The corresponding figures for Zurich are: 4000 starting addresses, 1931 successfully completed questionnaires, and a response rate of 48%. For the following analyses, we used only complete cases, that is, cases with valid values for all variables: 1442 in Mainz and 1586 in Zurich.

[2] For practical reasons, Dillman's procedure was slightly modified in the Zurich survey (see Bruderer Enzler et al. 2019, Chapter 4).

3.2 Variables and Their Operationalization

This section describes the dependent and independent variables in conjunction with some descriptive statistics. Methodological details on the construction of these variables can be found in the Appendix.

Environmental Protest: Our dependent variable is an additive protest index composed of six 0/1-coded protest behaviors ranging from participation in noise protest rallies up to engagement in local environmental action groups. The protest items also include "soft" forms of protest such as complaints to politicians or administrative agencies. The exact wording of the six protest items is documented in the Appendix. Descriptive results will be given in Sect. 4.1 (see Table 2).

Objective Road Traffic and Aircraft Noise: The information on "objective" road traffic and aircraft noise was not gleaned from the survey, but from external sources, namely official or organizational noise registers in Mainz and Zurich. Thus, the term "objective" here means simply that the information is based on such external sources. As already mentioned above (Sect. 3.1), the addresses of our respondents denoted their exact place of residence. We first determined the spatial coordinates for these locations using a GIS. For Mainz, this geocoding was carried out using a web-based service that extracts coordinates from Google Maps (http://www.gpsvisualizer.com/geocoder). For Zurich, coordinates were taken from the Federal Register of Buildings and Dwellings (Swiss Federal Statistical Office 2017). Subsequently, based on the GIS coordinates, very fine-grained statistical data on local road traffic and aircraft noise were merged with the survey data. Fine-grained data means these data focus directly on the building where the respondents lived. To capture road traffic noise and aircraft noise, weighted average 24-h noise levels L_{den} (level during the day, evening and night) were used. These were measured in decibels dB(A) and the usual penalties for evening and night-time noise of 5 dB(A) and 10 dB(A) were applied respectively (see Brink et al. 2018). Descriptive results on these objective noise variables, distinguishing between Mainz and Zurich, will be provided in Sect. 4.1 (Table 1).[3]

[3] We used the following sources for objective noise data: (1) Mainz road traffic noise: these data for 2012 were made available to us by the Grün- und Umweltamt Mainz (2017). L_{den} values were modeled in compliance with the established EU Environmental Noise Directive as a raster map on a 10-m grid. (2) Mainz aircraft noise: these data for 2016 came from the Umwelthaus Kelsterbach. Because only the equivalent values for 24 h (L_{eq}) and for the night (L_{night}) were made available to us, we followed Brink et al.'s (2018) suggestions and calculated approximate L_{den} values. (3) Zurich road traffic noise: these data for 2015 came from the Swiss National Noise Monitoring Database sonBASE (Swiss Federal Office for the Environment 2018). L_{den} was computed based on all façade points of the respondent's home address given that they were located within a 20-m radius of the geocoded address. (4) Zurich aircraft noise: these data for 2016, modeled according to the Swiss Noise Abatement Ordinance, were provided by the Flughafen Zurich AG (2017). Whereas these values differ slightly from L_{eq} values regarding the contribution of small aircrafts, these deviations can be considered negligible. Therefore, these values were treated as L_{eq} values in our computation of L_{den}. Because no separate measure for evening noise was available, L_{den} was computed by applying the same correction as used for Mainz (see Brink et al. 2018). We wish to thank the providing organizations for making available the noise data, and we are indebted to the experts in these organizations who helped us to process the data.

Subjective Road Traffic and Aircraft Noise: On a scale ranging from 0 (not annoyed at all) to 10 (highly annoyed), the mail survey asked respondents how annoyed they felt in their residence by various sources of noise (including road traffic and aircraft noise) under four different conditions: during the day when the residence's windows were open, during the day when windows were closed, during the night when windows were open, and during the night when windows were closed. Adding up these items on the four conditions and dividing the sum by four yielded indices of subjective road traffic and subjective aircraft noise. Again, for item wording, see the Appendix; and for descriptive results, see Sect. 4.1 (Table 1, Fig. 1).

Gender and Age: With regard to sociodemographic variables, we included "gender" (0 = male, 1 = female) and "age in years" (with a range spanning from 18 to 70). For the multivariate models, we divided age by 10, and additionally included age as a squared term. A total of 53% of the sample in Mainz and 54% in Zurich are female. The average age in Mainz is 42.8 years; in Zurich 42.7.

Education and Social Status: The respondent's social standing was measured by educational achievements and subjective status ranking. Educational achievements were simply captured as a dummy with 0 = low and 1 = high. High means a school degree allowing access to university. In Mainz, 71% of the respondents qualify as high; in Zurich 70%. These percentages indicate that our samples are biased in favor of people with high educational credentials. Concerning social status, subjects were asked to locate themselves on a scale ranging from 1 (belonging to a low-ranking social group) to 10 (belonging to a high-ranking group). Mean values on this status scale are 6.6 in Mainz and 6.5 in Zurich. The wording of the status item can be found in the Appendix.

Homeowner: This is a 0/1 dummy with code 1 if the respondent was the owner of his or her house or apartment, and code 0 if he or she rented it. A total of 39% in Mainz are homeowners in this sense; 22% in Zurich.

Environmental Concern: The measurement of general environmental concern was based on six items proposed by Diekmann and Preisendörfer (2001, 2003). These items, listed in the Appendix, focus on emotional, cognitive, and conative aspects of environmental problems. Participants were offered answers on a scale ranging from 1 (do not agree at all) to 5 (completely agree). An additive environmental concern index was constructed ranging from 1 to 5. Its mean value is 3.5 in both Mainz and Zurich.

Political Orientation: Whether respondents tended more toward a right- or a left-wing political ideology was measured on an 11-point scale ranging from 0 (right) to 10 (left). For the item wording, see the Appendix. The means on this item are 5.7 in Mainz and 6.0 in Zurich.

City Attachment: This is also a single-item measurement, aiming for the degree of personal identification with the city of residence. The Appendix shows the wording of this item that could be answered on a scale from 1 (no attachment at all) to 5 (very strong attachment). In Mainz, the mean is 3.6; in Zurich 3.7.

Motor Car Use and Air Flights: Motor car use is a 0/1 variable with code 1 for a car in the household that the respondent uses regularly. In Mainz, 80% are car drivers in this sense; in Zurich, 60%. Air flights is also a 0/1 variable with code 1 standing for respondents taking one or more flights in the last year. In Mainz, 60% report one or more air flights within that timeframe; in Zurich 78%.

Noise Sensitivity: Noise sensitivity was measured by five items on a five-point scale ranging from 1 (disagree) to 5 (agree). The items shown in the Appendix were adapted from Weinstein's noise sensitivity scale (Kishikawa et al. 2006). The additive index ranges from 1 to 5. Its mean value is 3.3 in Mainz and 3.1 in Zurich.

4 Empirical Results

Before dealing with the main research question (i.e., the impact of residential road traffic and aircraft noise on environmental protest) via multivariate analyses, a first subsection presents descriptive and bivariate findings.

4.1 Descriptive and Bivariate Findings

Our key independent variables are the objective and subjective noise measures described in Sect. 3.2. Their means, standard deviations, minimum and maximum values—for Mainz and Zurich respectively—are shown in Table 1.

Levels of objective road traffic noise are similar in the two cities, whereas objective aircraft noise is higher in Mainz than in Zurich. The World Health Organization (WHO 2018) strongly recommends that the average road traffic noise level L_{den} should be lower than 53 dB(A) and the average aircraft noise level L_{den} lower than 45 dB(A). The average road traffic noise of our survey respondents is close to the WHO recommendation both in Mainz (52.8 dB(A)) and in Zurich (53.4 dB(A)). The average aircraft noise is above the WHO recommendation in Mainz (47.6 dB(A)) and at the WHO limit in Zurich (45.3 dB(A)). In Mainz, 22% face an average traffic noise level L_{den} of 60 dB(A) or more; 30% an average aircraft noise level L_{den} of 50 dB(A) or more. The comparable values for Zurich are 21% and 11%. Thus, there are no differences with respect to objective road traffic noise, but the share of the population exposed to high aircraft noise is clearly higher in Mainz than in Zurich.

The means of the subjective road traffic noise are also very similar for the two cities. Because the means are not easy to interpret intuitively, Fig. 1 presents the full distribution of the subjective annoyances due to road traffic noise for the constellation of daytime, when the residence's windows are open. The first row of the diagram reveals that the distributions in Mainz and Zurich are quite parallel; 16% in Mainz

Table 1 Objective and subjective road traffic and aircraft noise in Mainz and Zurich

	Mainz ($n = 1442$)	Zurich ($n = 1586$)
Objective road traffic noise		
Mean	52.81	53.42
Standard deviation	8.39	6.76
Minimum	35.00	34.56
Maximum	80.00	75.62
Subjective road traffic noise		
Mean	2.37	2.42
Standard deviation	2.32	2.41
Minimum	0.00	0.00
Maximum	10.00	10.00
Objective aircraft noise		
Mean	47.65	45.34
Standard deviation	3.45	3.73
Minimum	40.81	36.26
Maximum	54.23	56.76
Subjective aircraft noise		
Mean	3.03	1.01
Standard deviation	3.08	1.78
Minimum	0.00	0.00
Maximum	10.00	10.00

Objective road traffic and aircraft noise measured by L_{den} in dB(A)
Subjective road traffic and aircraft noise measured on an annoyance scale ranging from 0 to 10

and 15% in Zurich feel highly annoyed (codes 8–10 on the scale) by road traffic noise.

With respect to subjective aircraft noise, the average annoyance level in Mainz is much higher than in Zurich. The means are 3.0 in Mainz versus 1.0 in Zurich (Table 1). The percentages of those feeling highly annoyed are 24% in Mainz compared with 4% in Zurich (second row in Fig. 1). Undoubtedly, the value of 24% highly annoyed by aircraft noise in Mainz can be viewed as very high, whereas the 4% in Zurich is surprisingly low given the recurrent public debate about aircraft noise in the metropolitan area of Zurich (Wirth 2004; Brink et al. 2008; Bröer and Duyvendak 2009). At the same time, the low share in Zurich is in line with the relatively low share of the population exposed to high objective aircraft noise levels.

Table 2 presents the frequencies of the six protest items adding up to the dependent variable of our empirical analyses: the environmental protest index.

With the exception of signing an environmental petition, the prevalence of protest activities is higher in Mainz than in Zurich. This holds especially true for participation in protest rallies (environmental protest rallies in general, noise protest rallies in particular). The additive protest index is 0.72 in Mainz and 0.60 in Zurich. Because the distribution of the protest index is skewed to the right, we shall take its natural logarithm (ln) for the following analyses.

In order to gain a first impression of the link between noise exposure and environmental protest, Table 3 provides the bivariate Pearson correlations of the four

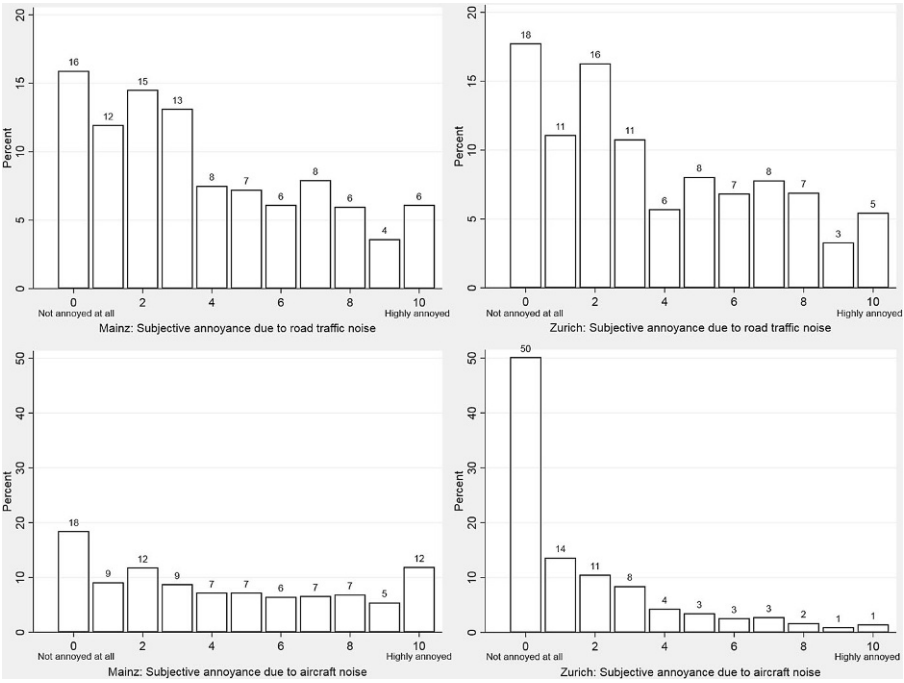

Fig. 1 Subjective annoyance due to road traffic and aircraft noise in Mainz and Zurich (during the day, windows of residence open)

noise measures and the protest index. The objective road traffic noise does not correlate with the environmental protest variable in either Mainz or Zurich. Subjective road traffic noise correlates significantly with protest, although these correlations are weak (0.08 and 0.11).

The correlations between aircraft noise and environmental protest in Mainz are more in line with our baseline expectation: Here, protest correlates with objective aircraft noise at 0.18, and with subjective aircraft noise at 0.36. For Zurich, however, it is quite a different picture: Here, the objective aircraft noise exposure correlates

Table 2 Frequencies (%) of environmental protest items in Mainz and Zurich

	Mainz ($n = 1442$)	Zurich ($n = 1586$)
Noise protest rally	9.2%	2.3%
Noise complaint	12.0%	9.5%
Environmental petition	30.7%	36.8%
Environmental complaint	4.7%	3.0%
Environmental protest rally	10.8%	5.1%
Local environmental action group	4.3%	2.9%
Protest index (mean)	0.72	0.60

Each item could be answered on a 0/1 scale (no/yes)
See Appendix for item wording

Table 3 Bivariate correlations of noise and protest variables in Mainz (M) and Zurich (Z)

	O-Road	S-Road	O-Aircraft	S-Aircraft
Protest	M: –0.05	M: 0.08*	M: 0.18*	M: 0.36*
	Z: –0.02	Z: 0.11*	Z: –0.07*	Z: 0.05
O-Road	–	M: 0.41*	M: 0.01	M: –0.11*
		Z: 0.48*	Z: 0.02	Z: –0.12*
S-Road	–	–	M: –0.03	M: 0.11*
			Z: 0.03	Z: 0.17*
O-Aircraft	–	–	–	M: 0.51*
				Z: 0.41*

No. of cases: 1442 in Mainz and 1586 in Zurich
O-Road objective road traffic noise, *S-Road* subjective road traffic noise, *O-Aircraft* objective aircraft noise, *S-Aircraft* subjective aircraft noise, *Protest* protest index
*Significant at 5% level

negatively with protest, whereas the subjective aircraft noise annoyance does not correlate significantly with the tendency to engage in protest.

The correlations between our objective and subjective noise measures in Table 3 also warrant a mention. For road traffic noise, these correlations are 0.41 and 0.48; for aircraft noise 0.51 and 0.41. This means that—at least on average—subjective assessments and evaluations of objective noise exposure seem to have a solid basis in real-life conditions.

4.2 Findings from Multiple Regression Models

As described in Sect. 2, a broad body of theoretical and empirical research indicates that environmental protest depends on several factors, and that direct exposure to local environmental hazards may be only one of them. Given this insight, we start our analyses with models that first ignore the local environmental risk parameters and include only a set of presumably relevant control variables. The results of this baseline model are summarized in Table 4.

In accordance with our hypotheses (Sect. 2.2), environmental concern proves to be a very strong stimulus of protest participation. Roughly gauged by the size of the *t* values of the regression coefficients, environmental concern is clearly the most important influence factor.[4] In second place is political orientation, with a left political worldview boosting the inclination to engage in protest. Education, too, turns out to be a strong predictor of protest behavior. We find a clear confirmation of the homevoter hypothesis—that is, homeowners compared with renters engage significantly more often in protest against residential noise. Furthermore, individual noise sensitivity positively affects protest participation. All remaining covariates either do not show significant effects (gender, social status, city attachment, motor car user, air flights last year) or yield significant effects in only one of the two cities

[4] Instead of standardized regression coefficients, we refer to the *t* values to gauge the relative strength of our covariates.

Table 4 Factors influencing participation in environmental protest in Mainz and Zurich (ordinary least-squares regressions)

	Mainz	Zurich
Gender (1 = female)	–0.207 (1.65)	0.189 (1.72)
Age in years/10	0.581* (1.97)	–0.216 (0.75)
Age squared	–0.050 (1.53)	0.024 (0.75)
Education (1 = high)	0.533* (3.50)	0.336* (2.49)
Social status	0.007 (0.17)	0.014 (0.41)
Homeowner (1 = yes)	0.387* (2.62)	0.397* (2.88)
Environmental concern	0.844* (9.11)	0.897* (11.50)
Left political orientation	0.168* (4.69)	0.208* (7.07)
City attachment	0.095 (1.42)	0.101 (1.67)
Motor car user (1 = yes)	0.077 (0.47)	–0.179 (1.54)
Air flights last year (1 = yes)	–0.089 (0.69)	–0.171 (1.25)
Noise sensitivity	0.388* (5.12)	0.162* (2.59)
Constant	–10.036* (13.31)	–7.581* (10.50)
Adjusted R^2	13.3%	20.3%
Number of cases	1442	1586

Unstandardized regression coefficients
t values in parentheses
*Significant at 5% level

(age). We will not comment on these results further, because they do not constitute the main impetus of our research.

Adding the noise variables to the models in Table 4 does not greatly change the effects of our control variables (not shown) and delivers the results reported in Table 5. When we additionally include only objective road traffic and aircraft noise in the models, there is only one significant noise effect: objective aircraft noise stimulates the protest activities of our respondents in Mainz. This does not hold true for Zurich. Furthermore, objective road traffic noise is not a significant driver of environmental protest in either Mainz or Zurich.

The pattern is more in line with the grievances and self-interest expectation, when—besides the control variables (of Table 4)—we take only the subjective noise measures into account: all regression coefficients have a positive value. Subjective road traffic noise is not significant in Mainz, but is significant in Zurich. Subjective aircraft noise is highly significant in Mainz, but not in Zurich.

Table 5 Objective and subjective road traffic and aircraft noise as factors influencing participation in environmental protest in Mainz and Zurich (ordinary least-squares regressions)

	Mainz	Zurich
Objective noise only		
Objective road traffic noise	–0.005 (0.68)	–0.004 (0.45)
Objective aircraft noise	0.094 (5.34)*	–0.029 (1.96)
Subjective noise only		
Subjective road traffic noise	0.033 (1.22)	0.060 (2.55)*
Subjective aircraft noise	0.158 (7.32)*	0.010 (0.30)
Objective and subjective noise		
Objective road traffic noise	–0.007 (0.92)	–0.017 (1.81)
Subjective road traffic noise	0.049 (1.64)	0.083 (3.00)*
Objective aircraft noise	0.035 (1.64)	–0.036 (2.16)*
Subjective aircraft noise	0.132 (4.96)*	0.030 (0.85)

All six models control for the set of covariates in Table 4
Number of cases: 1442 in Mainz and 1586 in Zurich
Unstandardized regression coefficients
t values in parentheses
*Significant at 5% level

Finally, Table 5 presents the results of models that include both objective and subjective noise. When controlling for objective road traffic noise, subjective road traffic noise tends to become a significant factor in Mainz (t = 1.64) and continues to be significant in Zurich. For aircraft noise, Mainz presents a very clear picture—with subjective noise retaining its significant influence after holding objective noise constant. The effect pattern for Zurich is unexpected and a little curious—the objective aircraft noise shows a significant negative effect, whereas the subjective variable yields a nonsignificant positive effect. It may be that the negative effect of objective aircraft noise has to do with the spatial distribution of aircraft noise in Zurich. Mainly, the northern districts of the city are affected by aircraft noise, and in these districts more socially disadvantaged people live who usually are less likely to participate in protest activities. But this remains speculation. We have seen that subjective aircraft noise is very low in Zurich and that simultaneously the measures of subjective and objective noise are correlated (r = 0.41)—and this is a constellation that jeopardizes a reliable and robust estimation of their effects. It seems reasonable to assume that—contrary to Mainz—aircraft noise does not affect protest participation in Zurich.

In addition to the protest index as a dependent variable, we estimated the models of Table 5 for all six 0/1-protest items separately. The basic results of these detailed analyses (binary logistic regressions) are compiled in Table 6.

The upper half of the table pertains to Mainz. Here, objective road traffic noise does not yield a significant effect for any of the six protest items. This "no effect pattern" also applies to subjective road traffic noise—with one exception, noise complaints to a public agency are positively affected by subjective grievances. Concerning aircraft noise, the pattern is that objective as well as subjective noise—taken individually—yields positive effects on the protest items; but the subjective noise

Table 6 Objective and subjective road traffic and aircraft noise as factors influencing participation in different forms of environmental protest in Mainz and Zurich (logistic regressions)

	NPR	NC	EP	EC	EPR	EA
Mainz						
Objective noise only						
Objective road traffic noise	ns	ns	ns	ns	ns	ns
Objective aircraft noise	s+	s+	s+	ns	s+	ns
Subjective noise only						
Subjective road traffic noise	ns	s+	ns	ns	ns	ns
Subjective aircraft noise	s+	s+	s+	s+	s+	ns
Objective and subjective noise						
Objective road traffic noise	ns	ns	ns	ns	ns	ns
Subjective road traffic noise	ns	s+	ns	ns	ns	ns
Objective aircraft noise	s+	ns	ns	ns	s+	ns
Subjective aircraft noise	s+	s+	s+	s+	s+	ns
Zurich						
Objective noise only						
Objective road traffic noise	ns	ns	ns	ns	ns	ns
Objective aircraft noise	ns	ns	s–	ns	ns	ns
Subjective noise only						
Subjective road traffic noise	s+	s+	ns	ns	ns	ns
Subjective aircraft noise	s+	ns	ns	s+	ns	ns
Objective and subjective noise						
Objective road traffic noise	ns	ns	ns	ns	ns	ns
Subjective road traffic noise	s+	s+	ns	ns	ns	ns
Objective aircraft noise	ns	ns	s–	ns	ns	ns
Subjective aircraft noise	s+	ns	ns	ns	ns	ns

All models control for the set of covariates in Table 4
Number of cases: 1442 in Mainz and 1586 in Zurich
NPR noise protest rally, *NC* noise complaint, *EP* environmental petition, *EC* environmental complaint, *EPR* environmental protest rally, EA local environmental action group
ns not significant, *s+* significant positive, *s–* significant negative

variable dominates when both subjective and objective aircraft noise are included in the models.

The lower half of Table 6 is for Zurich. Like in Mainz, objective road traffic noise shows no effects on protest. Subjective road traffic noise significantly influences the noise-specific protest items (noise protest rally and noise complaints), but not the others. With respect to objective and subjective aircraft noise, from a total of 24 single effects, 19 are not significant, three are significantly positive, and two significantly negative. Thus, the best conclusion undoubtedly is that aircraft noise is irrelevant for protest participation in Zurich.

All in all, road traffic noise is definitely a weak predictor of environmental protest in the two investigated cities. Aircraft noise exhibits a strong effect in Mainz, but no effect in Zurich. The pattern of regression coefficients supports the hypothesis that subjective noise annoyance is more important than objective noise exposure. The

"mediation hypothesis" finds confirmation only for aircraft noise in Mainz. For the other three constellations (road traffic noise in Mainz and in Zurich, aircraft noise in Zurich), the mediation hypothesis could not be tested seriously because the baseline assumption that objective noise would show a significant positive correlation with protest had already failed to hold true.

5 Discussion and Conclusions

Whether or not the self-interest and instrumentality motivation, following on from personal exposure to unfavorable conditions and the resulting grievances, stimulates participation in protest is a long-lasting and important question for both theoretical and practical reasons. In terms of theory, the self-interest model and the concept of selfish rational actors are controversially discussed in various disciplines of the social sciences. Even proponents of rational choice theory now differentiate between "thin" (i.e., strict, narrow) versions of the theory and "thick" (i.e., more moderate, wide) versions (Hechter and Kanazawa 1997; Opp 1999; Kroneberg and Kalter 2012). Thick versions are open to a broader range of preferences and motivations, and, under certain conditions, can also explain prima facie nonselfish behavior and individual contributions to collective goods (such as protest activities against noise pollution). In practice, a narrow self-interest motivation can cause societal problems and difficulties, but it can also have productive implications. When self-interest-driven protests gain widespread social momentum, collective projects with negative local externalities become more difficult to realize. Of course, this can also apply to issues in the field of environmental protection (e.g., finding sites for new wind and solar farms, or routes for high-tension power lines, see Ruddat and Sonnberger 2019). However, a self-interest motivation also implies that we can rely on the emergence of protests when local environmental threats get really "bad" and reach a level that directly endangers individual well-being.

With respect to the debate on the theoretical and practical role of grievances and self-interest, we started out from the observation that most of the previous studies dealing with the effect of local environmental "bads" on protest participation were based on poor measures of pressures and grievances. In our own study, we aimed to do better. We had the opportunity to use fine-grained data on both objective and subjective residential road traffic and aircraft noise to re-examine the "grievances hypothesis."

Centered on this measurement issue, the most important finding is that our analyses basically confirm the result of much previous research: unfavorable and annoying local conditions matter, often only under specific additional conditions, but they are only one protest motivator among others. Within the broader range of drivers of protest (here: environmental protest), their influence turns out to be relatively moderate. Individual worldviews such as environmental concern or a left-wing political ideology are more influential. Hence, unfavorable local environmental conditions can contribute to environmental mobilization, but they do not rank among the "top influences," their effect is not "straightforward" and often hinges on context-specific factors. Also, in line with much previous research, is our finding that subjective

perceptions and evaluations of disamenities are more important for protest reactions than objectively measured conditions. The presumed causal chain begins with objective threats, followed by subjective annoyances, and then reactions of opposition and protest.

Three further results, more specific to the setup of our study, deserve attention:

1. Aircraft noise seems to be more "protest-inducing" than road traffic noise. Although we expected this result on the basis of some plausible arguments (Sect. 2.2), the finding leads to the more general question of what types of local risks people perceive and evaluate as being especially dangerous and annoying and, thus, may be predominantly prone to mobilizing protest. In this view, future studies could attempt to embed different sources and types of noise and other environmental threats into the framework of socio-psychological risk research (see, for example, Slovic 2010).
2. The self-interest variable "homeownership" turned out to be a significant determinant of protest participation. This is in line with Fischel's (2001) homevoter hypothesis (Sect. 2.2). The group of home and apartment owners constitutes a potential for local environmental mobilization, which, up until now, has not been given much attention in the theory and practice of environmental protection.
3. A striking single result of our empirical analyses was the pronounced effect of aircraft noise on environmental protest in Mainz. A reasonable explanation for this finding can be made by way of reference to the supply-side influences on protest (Sect. 2.1). The Rhine/Main metropolitan area, which includes Frankfurt, Mainz, Wiesbaden, and Darmstadt, can look back over a history of local protests against aircraft traffic, beginning with the opposition against the construction of "Startbahn West" in the 1970s and early 1980s. This reasonably organized protest milieu has been reactivated by the opening of a new runway at Frankfurt Airport in October 2011 (Sect. 2.2). Since then, protesters have been meeting every Monday at Terminal 1 of the airport to express their concerns regarding aircraft noise and further airport expansion plans. The number of protesters varies from less than 100 up to more than 10,000 (reached mainly at the beginning). These regular protest events constitute an infrastructure and serve as platform, enabling network contacts for those who are personally annoyed by the negative consequences of the airport.

Like other studies, our study has weaknesses and limitations. The surveys pertain to two major cities and, thus, have a local restriction. Although we examined both objective and subjective noise parameters at the micro-level of individuals and households, the objective context and its subjective representation could have been characterized in greater detail. The information was confined to respondents' residential living situation at the time of the survey, but local environmental threats in earlier life episodes could be responsible for an individual's inclination to participate in protest. The surveys were cross-sectional, and this entails not only limitations in terms of data over time, but also difficulties with regard to identifying causal mechanisms. It cannot be ruled out, for example, that unfavorable residential conditions in the past motivated respondents to become active members in environmental action groups, and—over time—also to change their place of residence to a location with

comparatively favorable residential conditions. For such people, a cross-sectional study would find that their current exposure to environmental threats is low, but their activism is high. This observation would contradict the grievances hypothesis, but the real (dynamic) process remains undetected. Also related to processes over time, it could be argued that people do not react primarily to a given level of environmental threats but to changes in environmental conditions. Most people dislike changes to the status quo (status quo bias) and have a tendency to "make do" with current conditions. If this is true, it would be mainly significant changes to local environmental circumstances (such as the opening of a new runway at Frankfurt Airport) that could be expected to stimulate protest. Testing such hypotheses would require longitudinal data.

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Appendix

Measurement of the Dependent and Independent Variables

Environmental Protest: Question wording: (1) To reduce the noise level in your neighborhood, have you ever participated in a noise protest rally? (2) To reduce the noise level in your neighborhood, have you ever complained about noise to a state agency or a noise producer? (3) In the last five years, have you signed an environmental petition? (4) In the last five years, have you complained to a state agency or a political representative? (5) In the last five years, have you participated in an environmental protest rally? (6) In the last five years, have you been engaged in a local environmental action group? All items were no/yes (0/1) statements. An additive protest index was constructed ranging from 0–6. A principal components analysis shows that the protest items load on a single factor. Cronbach's alpha for the protest scale is 0.57.

Objective Road Traffic and Aircraft Noise: See text.

Subjective Road Traffic and Aircraft Noise: Question wording: To what degree do you feel annoyed in your residence by road traffic noise/aircraft noise (1) during the day when the windows of your residence are open, (2) during the day when the windows of your residence are closed, (3) during the night when the windows of

your residence are open, (4) during the night when the windows of your residence are closed? For each of the four conditions and separately for road traffic and aircraft noise, respondents answered on a scale from 0 (not annoyed at all) to 10 (highly annoyed). Additive indices of subjective road traffic noise and subjective aircraft noise were constructed with a range from 0 to 10 (sum of the four annoyances, divided by four). Principal components analyses show that the subjective road traffic as well as the subjective aircraft noise items load on a single factor. Cronbach's alpha for the subjective road traffic noise scale is 0.90, and for the subjective aircraft noise scale, it is 0.89.

Gender and Age: See text.

Education and Social Status: See text for education. Question wording for social status: There are different social groups in our society, some rank low, some high. Thinking about yourself: where would you locate yourself on the following scale from 1 (low ranking) to 10 (high ranking)?

Houseowner: See text.

Environmental Concern: Question wording: Using a scale from 1 (strongly disagree) to 5 (strongly agree), what is your position with respect to the following statements? (1) I am afraid when I think about the future environmental conditions for our children and grandchildren. (2) If we continue our current lifestyle, we run the risk of an environmental catastrophe. (3) The majority of people do not act in an environmentally responsible way. (4) In my opinion, environmental problems are greatly exaggerated by proponents of the environmental movement. (5) It is still true that politicians are doing far too little to protect the environment. (6) To protect the environment, we should be willing to constrain our current standard of living. An additive index of environmental concern was constructed with a range from 1 to 5 (item 4 reversed, sum of the six items, divided by six). A principal components analysis shows that the environmental concern items load on a single factor. Cronbach's alpha for the environmental concern scale is 0.80.

Political Orientation: Question wording: When it comes to characterizing somebody's political orientation, many people use the terminology "left-wing" versus "right-wing" to describe their basic political worldview. Thinking about yourself: where would you locate yourself on the scale from 0 (left) to 10 (right)? The item was reversed for the empirical analyses, that is, a high value indicates a left-wing political orientation.

City Attachment: Question wording: How strong is your personal attachment to the city of Mainz/Zurich? Respondents answered on a scale from 1 (no attachment at all) to 5 (very strong attachment).

Motor Car Use and Air Flights: See text.

Noise Sensitivity: Question wording: Please answer on a scale from 1 (strongly disagree) to 5 (strongly agree) whether you agree with the following statements. (1) I get annoyed when my neighbors are noisy. (2) I get used to most noises without much difficulty. (3) I find it hard to relax in a place that's noisy. (4) I get mad at people who make noise that keeps me from falling asleep or getting work done. (5) I am sensitive to noise. An additive index of noise sensitivity was constructed with a range from 1 to 5 (item 2 reversed, sum of the five items, divided by five).

A principal components analysis shows that the noise sensitivity items load on a single factor. Cronbach's alpha for the noise sensitivity scale is 0.78.

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