

Fairness in the Context of Aircraft Noise Management

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Summary

This dissertation explores the notion of fairness within the realm of aircraft noise research. The research conducted within this dissertation is part of the EU-project ANIMA (Aviation Noise Impact Management through Novel Approaches, Grant agreement No. 769627). Through three distinct research articles, it endeavors to shed light on various aspects of this concept. Firstly, the distribution of aircraft noise is elucidated as a fairness dilemma, and it is reviewed through the lens of social justice research. This examination draws upon prior insights from organizational and judicial psychology to provide a comprehensive perspective. Subsequently, a qualitative study delves into the experiences and viewpoints of residents who bear the impact of aircraft noise. The qualitative exploration aims to offer a nuanced understanding of how fairness is perceived from the view of aircraft noise affected residents. Lastly, building upon insights gathered from the preceding research, the development and validation of a questionnaire is shared. This questionnaire serves as a practical tool for quantifying fairness of airport management from the point of view of noise affected residents.

The thesis applies the four dimensions of fairness that are currently being distinguished in research: distributive fairness, procedural fairness, informational fairness, and interpersonal fairness to the issue of aircraft noise, and endeavors to identify strategies for their implementation. In light of the limited research available in this area, four critical gaps were identified: (1) the absence of a well-defined theoretical framework for fairness in aircraft noise research, (2) the limited amount of qualitative research with noise-affected residents to explore fairness in the aircraft noise discourse, (3) the lack of methodologies for quantifying fairness within aircraft noise research, and (4) the scarcity of empirical evidence regarding the impact of fairness on relevant outcome variables, such as annoyance due to noise, public acceptance of the airport and air travel and protest behavior against the airport. To address these gaps, three distinct research projects were conducted to comprehensively investigate fairness within the context of aircraft noise, aiming to provide a holistic understanding of its implications and significance.

The first article, *Aircraft Noise Distribution as a Fairness Dilemma - A review of Aircraft Noise through the Lens of Social Justice Research*, examines the allocation of aircraft noise as a complex issue concerning fairness. The article, a narrative literature review, considers the distribution of fairness as a dilemma and attempts to seek ways to improve the perception of fairness with help from current fairness research in other contexts, mainly organizational and judicial psychology. To this end, current theories of fairness are reviewed and considered in the

context of aircraft noise management. Ways to improve the perception of *distributive, procedural, informational* and *interpersonal* fairness of airport management are identified by drawing on research from other contexts, for example by improving the individual cost-benefit ratio, establishing fair procedures for aircraft noise related decisions and implementing a fair interaction between the airport and local residents.

In the second article, "*The Airport does what it wants to do anyway*" - *what constitutes a Fair Relationship with the Airport from the Perspective of Airport Residents? - a Qualitative Study Approach*, delves into the question of what constitutes a fair relationship between airport residents and the airport, as perceived by those affected by the noise. For this purpose, focus group discussions and in-depth interviews were carried out in the vicinity of several European airports. With the help of a qualitative content analysis, statements from participants were examined, and the extent to which the aforementioned four fairness facets are relevant from the perspective of noise affected residents was examined. The specific characteristics and particularly relevant aspects were identified, such as adequate compensation for the noise or a genuine and proactive involvement in processes and decisions at the airport concerning noise distribution. Based on these findings, a guideline was developed to facilitate the implementation of the identified aspects by airports, in order to build a neighborly relationship with affected residents.

The third article, *Being a Fair Neighbor - Towards a Psychometric Inventory to Assess Fairness-Related Perceptions of the Airport by Residents - Development and Validation of the Aircraft Noise-related Fairness Inventory (fAIR-In)*, describes the process of developing and validating a psychometric questionnaire. Nearly 100,000 flyers were distributed, resulting in a total of 1,367 completed data sets collected from residents living near Cologne-Bonn Airport, Düsseldorf Airport and Dortmund Airport. The development of these items was based on current research on fairness, expert consultations and qualitative insights from noise affected residents. The results of the confirmatory factor analysis depict a high model fit for the four factors of fairness also the aircraft noise research context. Furthermore, results indicate considerable correlations between all four fairness facets and the predictive variables of aircraft noise annoyance, acceptance of the airport and willingness to engage in protest. The questionnaire provides airport managers with a valuable tool, enabling them to effectively design, monitor, and evaluate interventions aimed at improving the relationship between the airport and nearby residents.

In summary, three research articles shed new light on the potential of social justice research in mitigating noise annoyance, low acceptance of the airport and air traffic and

potentially even protest behavior. This dissertation integrates a comprehensive literature review with both qualitative and quantitative research methods, thus delivering a holistic understanding of the significance of fairness within the realm of aircraft noise research. The published questionnaire summarizes theoretical knowledge gathered and the subsequent findings in the form of a practicable and easy-to-use research tool, expanding the scope of action for airport operators and noise researchers. In addition, it provides the basis for further research in the area of aircraft noise and can, thus, advance the understanding of development and mitigation of adverse reactions of noise affected residents.

Zusammenfassung

Die vorliegende Dissertation beschäftigt sich mit Fairness im Kontext der Fluglärmforschung. Die im Rahmen dieser Dissertation durchgeführten Untersuchungen sind Teil des EU-Projekts ANIMA (Aviation Noise Impact Management through Novel Approaches, Grant Agreement No. 769627). In drei verschiedenen Forschungsartikeln beleuchtet diese Thesis verschiedene Aspekte dieses Konzepts ganzheitlich.

In dieser Dissertation wird zunächst die Verteilung von Fluglärm als ein Fairness-Dilemma definiert und durch die Brille der sozialen Gerechtigkeitsforschung betrachtet. Dabei stützt man sich auf bisherige Erkenntnisse, vor allem aus der Organisations- und Rechtspsychologie. Anschließend werden in einer qualitativen Studie die Erfahrungen und Ansichten von Anwohnenden untersucht, die unter den Auswirkungen des Fluglärms leiden. Diese qualitative Untersuchung zielt darauf ab, ein nuanciertes Verständnis dafür zu entwickeln, wie Fairness aus der Sicht, der von Fluglärm betroffenen Anwohnenden, wahrgenommen wird. Aufbauend auf diesen Erkenntnissen, widmet sich diese Dissertation schließlich der Entwicklung und Validierung eines multidimensionalen und psychometrischen Fragebogens. Dieser Fragebogen ist ein nützliches Instrument zur Quantifizierung von fairnessrelevanten Aspekten des Flughafenmanagements aus Sicht der betroffenen Personen.

In dieser Thesis werden die vier Dimensionen der Fairness, die derzeit in der Forschung unterschieden werden: *distributive Fairness*, *prozedurale Fairness*, *informationelle Fairness* und *interpersonale Fairness* auf das Themengebiet der Fluglärmforschung angewandt und versucht, Strategien für deren Umsetzung zu identifizieren. Angesichts der begrenzten Forschung in diesem Bereich wurden vier relevante Forschungslücken identifiziert: (1) das Fehlen eines klar definierten theoretischen Rahmens für Fairness im Kontext der Fluglärmforschung, (2) ein Mangel an qualitativer Forschung, um Fairness aus Sicht der betroffenen Personen zu untersuchen, (3) das Fehlen von Methoden zur Quantifizierung von Fairness in der Fluglärmforschung und (4) der Mangel an empirischen Belegen für die Auswirkungen von Fairness auf relevante Variablen wie Lärmbelästigung, soziale Akzeptanz des Flughafens und des Flugverkehrs sowie die Protestbereitschaft gegen den Flughafen.

Um sich diesen Fragen zu stellen, wurden drei verschiedene Forschungsprojekte durchgeführt, um Fairness im Kontext der Fluglärmthematik umfassend zu beleuchten, mit dem Ziel, ein ganzheitliches Verständnis der Auswirkungen und Bedeutung zu entwickeln.

Der erste Artikel, *Aircraft Noise Distribution as a Fairness Dilemma – A review of Aircraft Noise through the Lens of Social Justice Research*, betrachtet die Verteilung von

Fluglärm als Fairnessdilemma. Der Artikel, eine narrative Literaturrecherche betrachtet die Verteilung von Fluglärm als Dilemma und versucht, mithilfe aktueller Fairnessforschung nach Möglichkeiten zu suchen, wie Fairness des Fluglärmmanagements verbessert werden kann. Zu diesem Zweck wurden aktuelle Theorien zu Fairness aufgearbeitet und auf den Kontext des Fluglärmmanagements angewandt. In dem Artikel werden Möglichkeiten identifiziert die Wahrnehmung von Fairness zu verbessern, indem beispielsweise das individuelle Kosten-Nutzen-Verhältnis verbessert wird, faire Prozesse bei Entscheidung zu der Verteilung von Fluglärm etabliert werden und eine faire Interaktionspolitik zwischen Flughafen und Anwohnenden aufgebaut wird.

Im zweiten Artikel *“The Airport does what it wants to do anyway.” What Constitutes a Fair Relationship with the Airport from the Perspective of Airport Residents? – A Qualitative Study Approach*, werden die Erkenntnisse aus vorangegangener Literaturrecherche qualitativ untersucht. Dafür wurden Fokusgruppendifkussionen und in-depth Interviews im Umkreis von mehreren europäischen Flughäfen durchgeführt. Mithilfe einer qualitativen Inhaltsanalyse wurden die Aussagen der Teilnehmenden analysiert und überprüft in wieweit die vier Fairnessfacetten aus Sicht von Betroffenen relevant ist. Die spezifischen Charakteristika und besonders relevanten Aspekte der Fairnessfacetten in vorliegendem Kontext wurden identifiziert, wie beispielsweise eine angemessene Kompensation für den Lärm den Personen ertragen müssen oder eine ernstgemeinte und proaktive Einbeziehung in Prozesse und Entscheidungen am Flughafen, die die Lärmverteilung betreffen. Basierend auf diesen Erkenntnissen wurde ein Leitfaden entwickelt, welcher Flughäfen dabei unterstützen soll, die identifizierten Aspekte zu implementieren um ein nachbarschaftliches Verhältnis zu betroffenen Anwohnenden aufzubauen.

Der dritte Artikel *Being a Fair Neighbor – Towards a Psychometric Inventory to Assess Fairness-Related Perceptions of the Airport by Residents – Development and Validation of the Aircraft Noise-Related Fairness Inventory (fAIR-In)* beschreibt den Entwicklungs- und Validierungsprozess eines psychometrischen Fragebogens. Nachdem fast 100.000 Flyer verschickt wurden, konnten insgesamt 1.367 komplette Datensätze von Personen die im Umkreis von Köln-Bonn Flughafen, Düsseldorf Flughafen und Dortmund Flughafen wohnen, gewonnen werden. Die Entwicklung der Items basiert auf aktuellen Theorien zur Fairness und bereits entwickelten Fragebögen aus dem Kontext der Organisationspsychologie, auf Expertenbefragungen von Forschenden, Flughafenauthoritäten und Lärmschutzbeauftragten und schlussendlich auch den Fokusgruppen. Die Ergebnisse der konfirmatorischen Faktorenanalyse zeigen, dass die Einteilung in die vier Facetten der Fairness auch im Kontext

der Fluglärmforschung die besten Ergebnisse liefert. Weiter konnte gezeigt werden, dass zwischen den vier Fairnessfacetten und den prädiktiven Variablen, Belästigung durch Fluglärm, Akzeptanz des Flughafens und des Flugverkehrs und der Protestbereitschaft eine hohe Korrelation besteht. Der fAIR-In kann Flughäfen dabei helfen, Interventionen, die die Wahrnehmung des Flughafens als fairen Nachbar in der Region verbessern sollen zunächst zu planen, zu begleiten und schlussendlich auch zu evaluieren.

Zusammengefasst werfen die drei Artikel, welche in dieser Dissertation vorgestellt werden, ein neues Licht auf das Management von Fluglärm durch die Perspektive der sozialen Gerechtigkeitsforschung. Die Dissertation kombiniert eine Literaturlarbeit mit qualitativen und quantitativen Forschungsmethoden und bietet so einen umfassenden Blick von Fairness im Kontext der Fluglärmforschung. Im veröffentlichten Fragebogen werden alle Erkenntnisse in Form eines praktikablen und einfach einzusetzenden Hilfsmittels zusammengefasst und erweitern somit den Handlungsspielraum von Flughäfen. Weiter kann der Fragebogen eine Basis weiterer Forschung sein, die sich mit Fairness im Kontext der Fluglärmthematik beschäftigt und das Verständnis von Einflussfaktoren auf die Entstehung und Intensität von Fluglärmbelästigung vertiefen.

1. Introduction

Environmental noise is one of the most important public health concerns and the negative impacts on human health and well-being is of increasing concern for both the general public and policy-makers in Europe (WHO, 2018). In times of constantly rising mobility demands, this issue is likely to become even more critical in the future, e.g. with regard to the air transport industry (ICAO, 2023).

Presently within the European Union, at least one in five individuals are exposed to long-term noise levels deemed harmful to their health (EEA, 2023). To quantify the adverse impact of environmental noise, the WHO Global Burden of Disease (GBD) was calculated utilizing disability-adjusted life-years (DALY), which combines the years of life lost due to premature mortality and the years of life lost due to time spent in less than optimal health states. In Western Europe alone, the estimated DALYs lost due to environmental noise are 903,000 years for sleep disturbance, 654,000 years for annoyance, 61,000 years for ischemic heart disease, 45,000 years for cognitive impairment in children, and 22,000 years for tinnitus (WHO, 2011). In Germany alone, 19.1% of the population is exposed to noise levels that can cause long-term negative health consequences (Umweltbundesamt, 2020).

In general, long-term exposure to environmental noise has been linked to a range of adverse health outcomes, including cardiovascular and metabolic diseases (van Kempen, Casas, Pershagen, & Foraster, 2018), adverse effects on sleep (Basner & McGuire, 2018), annoyance (Guski, Schreckenberg, & Schuemer, 2017), cognitive impairments (Clark & Paunovic, 2018a), impacts on quality of life, wellbeing and mental health (Clark & Paunovic, 2018b), adverse birth outcomes (Nieuwenhuijsen, Ristovska, & Dadvand, 2017) and tinnitus (Śliwińska-Kowalska & Zaborowski, 2017).

Noise annoyance is one of the most studied and established effects of noise, known to occur even at low levels of aircraft noise (Guski et al., 2017). Moreover, research has revealed that high levels of noise annoyance can serve as a mediator between long-term noise exposure and adverse health consequences (Brown & van Kamp, 2017; WHO, 2018), highlighting the importance of mitigating long-term annoyance among the population. Further exploration of the underlying reasons for this mediation effect of annoyance will be provided in Chapter 2.3.

Observing recent reviews regarding aircraft noise annoyance, it becomes evident that aircraft noise around airports labeled as high-rate change airports with recent or future changes in exposure tend to provoke heightened levels of annoyance among the residents living nearby than around so-called low-rate change airports with stable exposure (for an overview, see

Brown & van Kamp, 2009b). High-rate change airports comprise both airports with recently enforced, abrupt changes in aircraft movements and airports with announced changes, as an increase in the number of movements, expansions of the airport, changes in flight procedure or the building of a new runway (Brink, Wirth, Schierz, Thomann, & Bauer, 2008; Brown & van Kamp, 2009a; Fidell, Silvati, & Haboly, 2002; Guski et al., 2017; Janssen, Vos, van Kempen, Breugelmans, & Miedema, 2011). At airports with already implemented changes, increased annoyance ratings are explained by an excessive response to the change, often referred to as an overreaction among residents (Job, 1988b). Brink et al. (2008) demonstrated that individuals living near airports experience heightened annoyance due to a sudden rise in noise levels, showcasing an amplified reaction in response to this alteration. For airports with changes yet to be implemented, van Kempen and van Kamp (2005) hypothesized that a public awareness and expectations regarding changes in noise exposure may lead to an increase of annoyance, even before changes of noise exposure occur, indicating the influence of psychological factors on residents' reactions.

This suggests that it is not solely the intensity of noise but also the unpredictability and procedural aspects in airport operations that contribute to increased annoyance among residents. Furthermore, changes at the airport, like the building of a new runway often lead to conflicts, protests and community activism (Wiebusch, 2014). For example, the opening of the fourth runway at Frankfurt Airport in Germany sparked a series of protests and counter-movements aimed at addressing the airport's impact on the local community (Guski et al., 2017). Similarly, plans of Dortmund Airport to expand night flights have elicited complaints from residents who are concerned about increased noise and the potential negative effects on their quality of life (tagesschau, 2023). Changes at the airport often cause uncertainty among affected individuals, regarding changes in noise levels and their personal and psychological ability to cope with the increase in noise. In addition, changes or expansions at the airport often come along with an increase in flight movements, or at least a rearrangement of departures and / or approach routes, resulting in a redistribution of noise. This redistribution of noise can lead to conflicts because some residents will experience an increase in noise exposure, while others may find relief from an additional burden. Consequently, conflicts between the airport and affected residents are primarily linked to decisions that result in specific noise exposures.

Unlike natural sounds like bird songs, aircraft noise is a human-made phenomenon and can be regarded as a form of social interaction (Maris, 2008). In essence, exposure to human-made noise is often described as a social experience (Maris, 2008). For residents living near airports who are exposed to aircraft noise, this relationship can be summarized as "YOU expose

ME" (van Gunsteren, 1999), and those affected often hold the airport operator responsible for their exposure to aircraft noise (Maris, 2008). The noise that residents have to endure can be seen in this context as a constant reminder of unfair treatment by the airport. The feeling of being treated unfairly can eventually trigger a strong emotional reaction and may explain the motivations behind protest movements against the airport (Rothmund, Baumert, & Zinkernagel, 2014). Therefore, the experience of aircraft noise is intertwined with decisions made by people and is, thus, an aspect of *fairness*.

This raises an important question: when do we consider something to be *fair*?

The concept of fairness or justice ¹ has deep roots, dating back over two thousand years to Aristotle, who described justice in terms of equality and a proportional distribution of commensurable goods (Chroust & Osborn, 1941). More recently, theories like equity theory (Adams, 1965) or relative deprivation theory (Runciman & Runciman, 1966) highlighted that individuals evaluate fairness based on social comparison of cost-benefit ratios. Fairness is therefore perceived when cost-benefit ratios between individuals are perceived to be equivalent. When individuals feel they are deprived relative to what they expect or deserve, or when they compare themselves to others, it can lead to feelings of anger and rumination (Smith, Pettigrew, Pippin, & Bialosiewicz, 2012). However, it is important to note that the outcome itself is not always the sole predictor of whether something is considered fair. Research has shown that when people have a voice and participation opportunities during the decision-making process, they are more likely to perceive the outcome as fair and evaluate it positively, regardless of the final decision (Folger, Rosenfield, Grove, & Corkran, 1979). When decisions are made by third parties or legal authorities with consequences for individuals, fairness is more likely to be perceived when individuals have some degree of control in the decision-making process. This “fair process effect”, has been extensively studied, especially in the organizational and judicial psychology and revealed that establishing fair procedures have an impact on pay evaluations (Tyler, 2000; van den Bos, Lind, Vermunt, & Wilke, 1997a), job satisfaction (Alexander & Ruderman, 1987), trust in management, organizational commitment and job performance (Colquitt, Conlon, Wesson, Porter, & Ng, 2001). Research from organizational psychology has also emphasized the importance of the quality of interaction between involved parties in regard to perceiving something to be fair. Interactional justice research (Bies & Moag, 1986) suggest that the quality of explanations justifying the reason for decisions and a respectful behavior of

¹ The two terms are used interchangeably throughout this thesis.

the decision-maker, treating people with politeness and dignity further impacts the perception of fairness (Greenberg, 1993). The aspect of fairness, as well as insights into the psychological mechanisms, are explained in more depth in Chapter 2.5.

Research on the perception of fairness highlights crucial factors that shape how decisions are perceived as fair or unfair (for an overview, see Colquitt et al., 2001). It underscores the importance of the decision-making process itself in determining the overall acceptance and satisfaction with outcomes (Bobocel & Gosse, 2015; Folger, 1977; Greenberg & Folger, 1983; Leventhal, 1980; Thibaut & Walker, 1975). Moreover, this research emphasizes the fundamental elements of fairness, such as an honest and transparent dissemination of information and the respectful treatment of those affected by the decision (Bies, 1986; Greenberg, 1993). Research has shown that this substantially influences the overall satisfaction with decisions (e.g. Greenberg, 2000; Lind, Walker, Kurtz, Musante, & Thibaut, 1980; Tyler, 2000).

Aircraft noise, being a direct consequence of human decisions related to airport operations, is inherently tied to the concept of fairness. Important aspects in this context, such as noise annoyance, low acceptance of airport decisions, protest behavior, and general distrust towards airports can be seen as manifestations of a perceived lack of fairness in the way decisions are made and their impacts are managed. Recognizing this connection between fairness and noise-related outcomes, highlights the potential for insights from fairness research in other contexts to substantially improve aspects of aircraft noise management.

However, it is important to note that, until now, the findings from fairness research have not been systematically and thoroughly applied to the specific context of aircraft noise research. Incorporating fairness principles into the context of aircraft noise research can provide a more holistic understanding of the issues at hand and offer potential strategies for addressing them, based on empirical research in other contexts. By doing so, we may be able to enhance the overall experience of individuals living near airports, minimize noise annoyances, and foster greater acceptance and trust in airport decision-making processes. This recognition of the role of fairness in aircraft noise research opens up new avenues for investigation and potential solutions to longstanding challenges in the field.

Recognizing fairness to be a crucial factor in understanding reactions to aircraft noise, like annoyance, the acceptance of the airport or general motivation of protest, form the foundation for this dissertation's objectives, which seek to establish the concept of fairness within the realm of aircraft noise research. This thesis addresses theoretical, methodological, and empirical aspects of fairness within the context of aircraft noise research. The primary

considerations and findings are presented in three articles, which have either been published in peer-reviewed journals or submitted for publication. Before delving into the articles, I offer general theoretical background of aircraft noise research and explain in more detail why fairness might be a pertinent aspect in aircraft noise research (Chapter 2). This theoretical background gives rise to seven research questions that remain unanswered due to the limited existing research in that field (Chapter 3). In Chapter 4, the three peer-reviewed articles are summarized and their contribution are elucidated addressing these research questions. The three research articles are detailed in Chapter 5, 6 and 7. In the subsequent Chapter 8, I consolidate the findings, summarizing the theoretical, methodological, and empirical contributions made by this research. Finally, I outline potential future research projects that could further advance our understanding of the importance and effects of fairness in the field of aircraft noise research (Chapter 9).

2. Fairness in Aircraft Noise Research: A Missing Perspective

In order to grasp the concept of fairness within the realm of aircraft noise research from a psychological standpoint, current research areas will be explored in more detail. First, the general health effects of environmental noise are outlined. Secondly, the aspect of aircraft noise induced annoyance, a pivotal focus in the aircraft noise discourse, will be discussed as one of the most important effects of aircraft noise. Subsequently, the theoretical framework of aircraft noise annoyance, elucidating its origins and potential mitigation aspects will be considered. Lastly, research findings will be synthesized concerning non-acoustic factors that affect aircraft noise annoyance, before delving into the multifaceted dimension of fairness and the relevance it has in the context of aircraft noise research.

2.1 General health effects of environmental noise

Whilst the noise from aircraft is for the most part too low to cause biological damage to the ear, long-term noise exposure can lead to a variety of adverse non-auditory health effects (Ancona et al., 2014). These adverse health effects are diverse and include most prominently annoyance due to noise, which will be covered in more detail in the next section (Bartels, 2014; Fidell et al., 1985; Guski et al., 2017; Quehl & Basner, 2006) and disruption of sleep during nighttime (Bartels, Quehl, & Aeschbach, 2019; Basner & McGuire, 2018; Halperin, 2014; Smith, Cordoza, & Basner, 2022), but also associations with cardiovascular diseases (van Kempen et al., 2018) such as occurrences of myocardial infarction (Babisch, Beule, Schust, Kersten, & Ising, 2005), instances of coronary heart disease (Babisch, 2014; Roca-Barceló et al., 2021), and impacts on blood pressure (Dratva et al., 2012). The deleterious influence of long-term environmental noise exposure has already been observed in infants and children, affecting their health, perception, and learning abilities, as exemplified by the deterioration of reading and oral comprehension skills among school-aged children (Bartels et al., 2019; Klatte, Bergström, & Lachmann, 2013; Klatte et al., 2017; Quehl, Bartels, Fimmers, & Aeschbach, 2021).

Overall, the effects of long-term aircraft noise are multifaceted. However, the aspect of annoyance is given special attention in research, which will be detailed in the subsequent section.

2.2 Noise Annoyance as one of the main effects of environmental noise

Environmental noise is a pervasive source of irritation, particularly in urban areas, and is frequently attributed to various forms of transportation, including aircraft, road traffic, rail

traffic, and industrial activities. Among the myriad effects of noise, annoyance stands out as a prominent one (Bartels et al., 2022; Guski et al., 2017). In fact, more than half of 68 international experts that responded to an expert interview have identified annoyance as the primary consequence of noise exposure (Guski, Felscher-Suhr, & Schuemer, 1999).

Annoyance also acts as a mediator linking noise to other detrimental health outcomes, underscoring the significance of research on annoyance (Brown & van Kamp, 2017; WHO, 2018). Findings support the hypothesis that annoyance plays a mediating role in the relationship between aircraft noise exposure and health outcomes with regard to cardiovascular health (Babisch et al., 2013; Baudin et al., 2020; Eriksson, Bluhm, Hilding, Östenson, & Pershagen, 2010), decreased reported physical well-being (Schreckenberg, Benz, Belke, Möhler, & Guski, 2017a) and increased psychological distress (Baudin, Lefèvre, Laumon, & Evrard, 2018). Furthermore, individuals reporting higher levels of annoyance due to noise take more medication to treat anxiety disorders (Baudin et al., 2021). In additional studies, aircraft noise did not have a direct effect on factors related to mental health-related quality of life (Schreckenberg et al., 2017a), or diagnoses of depression (Benz & Schreckenberg, 2019), but an indirect effect via annoyance. In sum, evidence suggests that annoyance at least partly mediates the path from exposure to decreased mental and physical health. Given these implications, it becomes crucial to comprehend the origins and perpetuating factors of annoyance in greater detail. Doing so not only helps alleviate annoyance itself but also contributes to the management of the health-related consequences associated with it, ultimately enhancing the quality of life for residents living near airports.

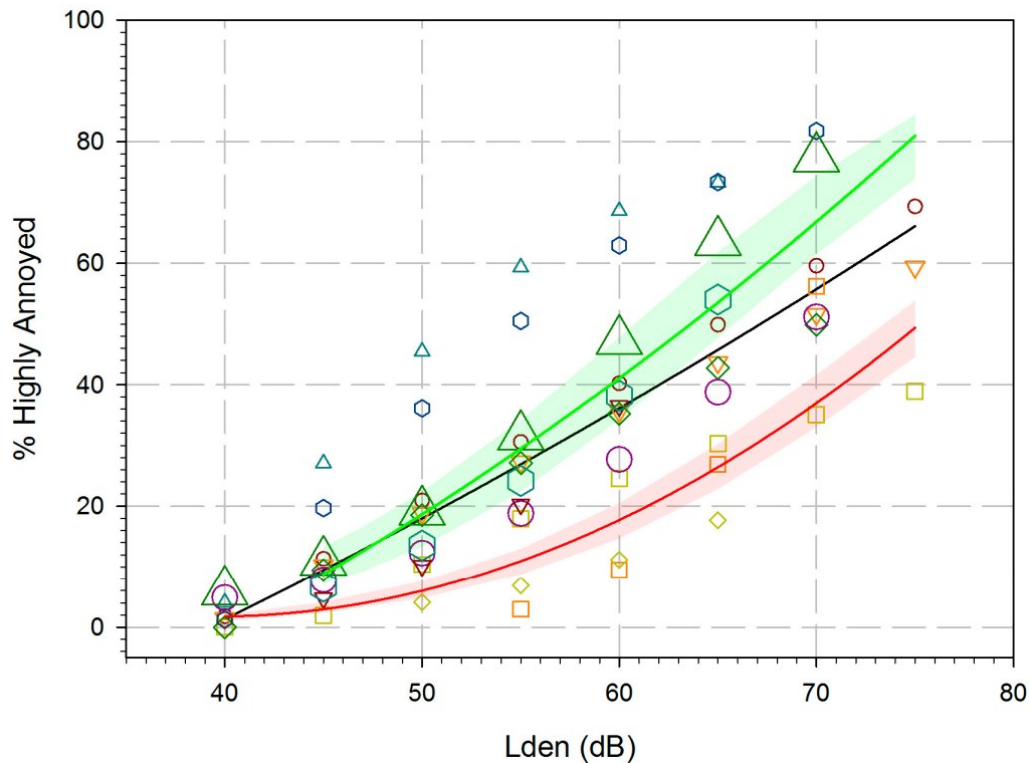
Noise annoyance is typically defined by three central elements. These are (1) a repeated disturbance by the noise, e.g. during communication with a person, reading or watching TV, often resulting in a behavioral response to minimize the disturbance e.g. closing a window, (2) an emotional or attitudinal response, e.g. through experienced anger or negative evaluation of the noise emitter, and (3) a cognitive response, e.g. through the distressing realization that there is (almost) nothing they can do about the unwanted noise (Guski et al., 2017).

The World Health Organization (WHO) also places great importance on annoyance as a significant health concern, ranking closely behind sleep disturbance (Guski et al., 2017). Annoyance is not only extensively studied, but also serves as a valuable metric for estimating the impact of noise and is instrumental in shaping legislation (Benz et al., 2022). Researchers have developed exposure-response relationships (ERR) to illustrate the relation between sound exposure and the number of individuals experiencing high levels of annoyance (Guski et al., 2017; Miedema & Oudshoorn, 2001; Miedema & Vos, 1998; Schultz, 1978). As an acoustical

measure for the sound exposure, L_{Aeq} or L_{den} is widely used in such studies. The L_{Aeq} , the energy equivalent sound pressure level, is a measure that summarizes the time average of all sound pressure levels within an observation period, according to specified rules and is a well-established and acknowledged measure to quantify noise exposure. The L_{den} (day-evening-night), corresponds to L_{Aeq} , with 10 dB(A) penalties for the night-time (23:00 to 07:00), or 5 dB(A) penalties for the evening (19:00 to 23:00). The L_{den} is also used for noise maps in accordance with the Directive 2002/49/EC (2002) for the European Union and is the base for assessment and management of environmental noise.

In Figure 1, extracted from the WHO review for environmental noise annoyance (Guski et al., 2017), one can observe the statistical relationship between noise levels in decibels and the estimated percentage of highly annoyed individuals (%HA) across different exposure categories, representing various studies. To measure annoyance, the 5-point verbal or 11-point numerical ICBEN Question is internationally established according to ISO/TS 15666 and asks "Thinking about the last 12 months, when you are here at home, how much does noise from aircraft bother, disturb, or annoy you?" (Clark et al., 2022; Fields et al., 2001). Based on this, in the WHO review for environmental noise annoyance, 'highly annoyed' (HA) is defined by the top 27% of the responses of the 11-point numerical ICBEN annoyance scale (Guski et al., 2017), which is similar to the HA_N -Definition according to the revised ISO/TS 15666:2021.

The black curve in the figure represents aggregated data and can be interpreted as the exposure-response curve for the complete dataset for aircraft noise included in the meta-analysis of the WHO review by Guski et al. (2017). This curve provides valuable insights into how noise levels correspond to the likelihood of individuals experiencing high levels of annoyance. These ERRs are often used for regulatory purposes to predict the prevalence of annoyance for a certain amount of noise (for e.g. in Annex III of the EU Directive on the health impact assessment of environmental noise 2002/49/EC (2002)).

Figure 1. Exposure-Response Relationships between Aircraft Noise and Annoyance

Note. Different Exposure-Response Relationships (ERR) between Aircraft Noise (L_{den}) and the percentage of individuals highly annoyed (%HA), taken from (Guski et al., 2017).

Nonetheless, it is worth noting that recent studies have demonstrated significant deviations from these curves, especially in areas around airports where changes occur (Brink et al., 2008; Janssen et al., 2011; van Kempen & van Kamp, 2005).

Even more noteworthy is the fact that studies focusing on environmental noise annoyance have revealed that acoustic factors, i.e., the noise itself, can only explain a relatively small portion of the variation in annoyance reactions. In a meta-analysis conducted for the World Health Organization's Environmental Noise Guidelines, encompassing a total of 18,947 respondents, the correlation between noise and annoyance was found to be relatively low, with correlations ranging from $r = 0.21$ to $r = 0.74$, and a mean correlation of $r = 0.436$ (Guski et al., 2017). In essence, only 19% of the variation in aircraft noise annoyance (in raw scores) can be attributed to variations in the noise levels, measured in L_{den} (Guski et al., 2017).

Over the years, there have been repeated efforts to enhance the predictability of noise annoyance through the development of better mathematical models (Fidell, Barber, & Schultz, 1991; Guski et al., 2017), introducing alternative metrics for a more accurate depiction of noise exposure's impact on individuals (Haubrich et al., 2019), and controlling other confounding

variables (Bartels et al., 2022; Schreckenberg, Benz, Kuhlmann, Conrady, & Felscher-Suhr, 2017b). Regrettably, none of these endeavors have significantly improved the ability to predict noise annoyance.

However, researching factors that impact noise annoyance and understanding the aspects that play a role is crucial, since annoyance is assumed to mediate adverse health effects of noise, thus, having a crucial impact on the quality of life of residents living around the airport. Given that the acoustic factors alone fail to satisfactorily account for the variation in annoyance among airport residents, researchers have increasingly turned their attention to non-acoustic factors (Bartels et al., 2022; Flindell & Stallen, 1999; Guski, 1999; Job, 1988a; Maris, Stallen, Vermunt, & Steensma, 2007a, 2007b; Miedema & Vos, 1999; Quehl et al., 2021; Riedel et al., 2021; Schreckenberg, 2022; Stallen, 1999).

Before delving into an overview of research on non-acoustic factors in the upcoming section, it is essential to establish a clear understanding of why these non-acoustic factors are regarded as key aspects in the development and persistence of annoyance. Therefore, the following section will examine the psychological model for noise annoyance in more detail to elucidate the connection between non-acoustic factors and the experience of annoyance due to aircraft noise.

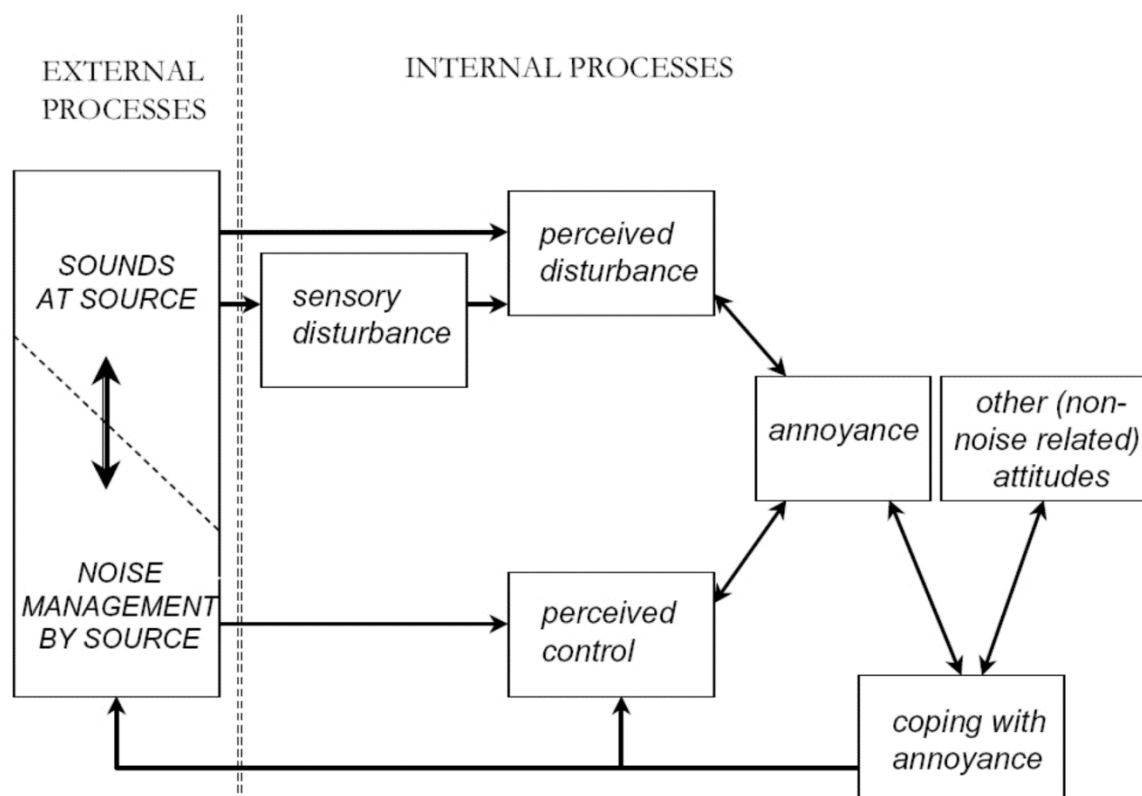
2.3 The Psychological Model for Noise Annoyance

Noise annoyance is fundamentally a psychological phenomenon (Stallen, 1999). Moreover, the perception of noise itself can be understood through a psychological lens, as whether a *sound* is deemed *noise* depends on individual evaluation. For example, someone in the front row of a concert they willingly attended may not perceive the loud music as noise, while nearby residents may categorize the same sounds as noise.

The theoretical framework (see Figure 2) proposed by Stallen (1999) explores the psychological aspects of annoyance and draws from stress theory (Lazarus & Folkman, 1984) to explain its persistence and potential remedies. From a psychological perspective, annoyance stems primarily from the sensation of disturbance that is unwelcome or disliked. For instance, if noise disrupts an individual's ability to comprehend an important phone call, it can lead to feelings of annoyance. Guski et al. (1999) define annoyance as "a relation between an acoustic situation and a person who is forced by noise to do things he/she does not want to do, who cognitively and emotionally evaluates this situation and feels partly helpless" (Guski et al., 1999, p. 525). Within this framework (Stallen, 1999), annoyance can be viewed as a stress response, which, if prolonged, triggers physiological reactions, such as the activation of the

pituitary-adrenal-cortical axis and the sympathetic-adrenal-medullary axis, releasing stress hormones like epinephrine, norepinephrine and cortisol (Babisch, 2002). Recognizing annoyance as a stress response is the key reason why it might play a mediating role in the context of adverse health outcomes, as mentioned in Chapter 2.2.

Figure 2. Theoretical Model of Noise Annoyance



Note. The theoretical framework of Noise Annoyance (Stallen, 1999), viewing it as a stress response to the external stimuli “sounds” and “noise management”.

In this framework, perceiving stress results from regarding an external stimulus as a threat and one's ability to manage that threat through cognitive and emotional processes (see Figure 2). Therefore, annoyance, much like stress, can be seen as a consequence of the dynamic interplay between perceived disturbance and perceived control.

Lazarus' psychological stress model (1984) introduces two critical stages of appraisal: primary appraisal and secondary appraisal. In primary appraisal, individuals interpret the stressor at hand, and this evaluation can yield three categories: positive, irrelevant, or

dangerous. The *dangerous* category can further differentiate between perceiving the stressor as a challenge, a threat, or a loss. According to Stallen (1999), noise mitigation measures primarily influence primary appraisal by directly reducing the sound level, which affects the initial assessment of the stressor.

On the other hand, non-acoustic factors like predictability and trust are linked to perceived control and constitute part of the secondary appraisal process. According to Lazarus' stress model (1984), these factors contribute to reducing uncertainty and shape how individuals evaluate their ability to cope with or manage the stressor.

In summary, annoyance results from the interplay between perceived disturbance and perceived control. Strategies to reduce annoyance can involve either mitigating disturbance, such as through sound insulation, or enhancing psychological control, for instance, by fostering trust in noise prevention measures. This reduction in annoyance occurs by diminishing the perceived level of stress, a central concept in Lazarus' stress model (1984).

Perceived control encompasses various factors within Lazarus' model, serving as part of the secondary appraisal process. These factors mainly work to reduce psychological uncertainty. Stallen (1999) underscores that perceived control is a pivotal non-acoustic factor influencing annoyance. He highlights that individuals can experience psychological control in multiple ways, including mental control, e.g. by being able to predict future noise exposures, behavioral control, e.g. by adjusting noise exposure, or closing windows, and managing noise at its source. Notably, in Stallen's theoretical framework (1999), perceived control holds a central and moderating role in the generation of noise annoyance.

The framework described (Stallen, 1999) suggests that annoyance can be seen as a stress response, and is a dynamic and evolving process, continually assessed and re-evaluated as acoustic and non-acoustic variables change. It underscores the intricate interplay between the perception of disturbance and perceived control in shaping individuals' experiences of annoyance in response to noise.

Empirical evidence from the study by Kroesen, Molin, and van Wee (2008) supports this as a valid theoretical framework for understanding the mechanisms behind noise annoyance and its underlying causes, by conducting a structural equation model. In essence, the results reinforce the idea that psychological and non-acoustic factors play a crucial role in shaping how individuals respond to and are affected by noise. In addition, the notion that noise annoyance is a stress response is further emphasized in the model by Babisch (2002), which also highlights the mediating role of this stress response on adverse health outcomes. In Chapter 2.5, the significance of fairness in enhancing psychological control is elucidated. In essence, it can be

posited that fairness research unveils a multitude of pathways through which perceived control can be attained, thereby making a substantial contribution to enhancing the perceived control within Stallen's model (1999). Before doing so, a concise summary of the most important findings that have been made on non-acoustic factors in the context of aircraft noise annoyance research and their connection to fairness aspects is given.

2.4 Non-acoustic Factors influencing Noise Annoyance

Having gained a more comprehensive understanding of noise annoyance as a stress response, the aim is now to provide a concise overview of the principal findings pertaining to non-acoustic factors in noise annoyance research. As mentioned earlier, studies have consistently shown that acoustic factors alone are insufficient to explain the variety of annoyance responses (Guski et al., 2017).

Non-acoustic factors, in this context, refer to elements that influence the level of annoyance caused by aircraft noise and are not directly related to objectively measured noise metrics, such as sound levels, peak levels, spectrum, and noise event frequency. Non-acoustic factors are estimated to contribute to at least one-third of the annoyance response, while another third of the variance in annoyance remains associated with factors that are presently unknown (Guski, 1999).

Personal and social factors, encompassing attitudes, concerns, and expectations regarding future noise scenarios, are among the most important non-acoustic factors associated with annoyance (Fields, 1993; Guski, 1999; Miedema & Vos, 1999). Concerns related to potential long-term health effects, fears of aircraft crashes, and expectations of worsening noise conditions have further been shown to significantly increase annoyance (Kroesen et al., 2008; Schreckenberg, Meis, Kahl, Peschel, & Eikmann, 2010). Conversely, a positive evaluation of the entity responsible for the noise, viewing it as a contributor to the local economy, reduces perceived annoyance (Schreckenberg et al., 2010).

Research has also identified stable personality traits impacting the perceived annoyance, such as noise sensitivity, characterized by a general susceptibility to noise, has been identified as one of the most influential variables in noise annoyance (Gille, Marquis-Favre, & Weber, 2017; Zimmer & Ellermeier, 1998).

In a further study (Kroesen et al., 2008), the theory of the formation of noise annoyance was examined by means of a structural equation model, pointing at additional non-acoustic factors. These factors included concerns about potential negative health effects of noise and

pollution, perceived control, coping capacity, and negative expectations regarding noise development. Remarkably, these non-acoustic factors were found to have the most substantial influence on noise annoyance (Kroesen et al., 2008).

In alignment with Stallen's theoretical model (1999), perceived control and the ability to cope with noise are crucial non-acoustic factors in experiencing noise annoyance. Studies have demonstrated that people react less strongly to noise when they can predict when to expect noise (Glass & Singer, 1972) or when they have indirect control over noise, such as through communication strategies (Liebe, Preisendörfer, & Enzler, 2020; Maris, 2008; Stallen, 1999). Trust in noise management institutions is another important non-acoustic factor, as it reflects the belief that noise sources are actively working to reduce unnecessary noise and prioritize residents' health.

Coping capacity and the psychological aspect of perceived control are not solely aspects which rely on the noise affected residents themselves. In fact, the behavior of the noise source, in this context the airport managers play a crucial role in perceiving high noise annoyance (Guski, 1999; Stallen, 1999). A variety of non-acoustic factors mentioned, such as trust, providing accessible and transparent data on noise levels, acknowledging the health effects of noise, and engaging with noise affected residents depend on the behavior of the noise source, highlighting the social aspect of perceiving aircraft noise. In summary, the aforementioned factors can be summarized with one concept: *fairness*.

2.5 Fairness as an Underlying Construct

The concept of fairness encompasses a range of theories and ideas, all attempting to answer questions like "what is fair?" and "how do people perceive (un)fairness?"

As mentioned in the introduction, the concept of fairness has ancient origins, tracing back more than two thousand years to Aristotle, who defined justice as the equitable and proportional distribution of commensurable goods (Chroust & Osborn, 1941). From a philosophical standpoint, fairness, or justice, can be described in a way that requires every member of a society to adhere to the same principles of justice and assume that others do the same (Rawls, 1971). Rawls (1971) further emphasizes that it is not only individuals who play a role in this, but also crucial social institutions that should uphold these principles. According to Rawls (1971), the allocation of resources should be done in such a way that all people, regardless of social status, profession, familial background, intelligence or gender, should have equal opportunities within society.

One of the earliest psychological theories around fairness comes from Adams (1965) who posits that *equity*, equal to fairness, is perceived when the cost-benefit ratio between individuals is perceived equivalent. Adams (1965) asked in this theory, whether a disadvantage would result from a decision, more than a mere feeling of dissatisfaction. In the *relative deprivation theory*, anger and rumination are triggered when individuals perceive themselves to be deprived relative to what they expect to deserve or in relation to what others receive (Runciman & Runciman, 1966; Smith et al., 2012). The *referent cognition theory* also maintains a similar idea, stating that people most likely experience a sense of injustice when they are disadvantaged in relation to someone else (van den Bos & van Prooijen, 2001).

All of these theories focus on the idea that fairness primarily hinges on whether decisions result in individuals being disadvantaged when they don't receive what they deserve. In sum, these theories essentially address *distributive fairness*, which pertains to the equitable allocation of goods or costs. Leventhal (1976) explored further how goods or costs should be distributed to be perceived as fair and postulated some guiding principles. Firstly, a distribution can be equally distributed to all individuals in the sense of the *equality rule* (Leventhal, 1976). This aligns with the concept of receiving fair compensation for one's work, regardless of the individual. Secondly, the *needs rule* (Leventhal, 1976) suggests that distribution should be tailored to accommodate individuals who are particularly vulnerable or in greater need, providing them with a larger share of the distribution or reducing their costs. Additionally, another distribution approach stems from the ideas of Mill and Bentham (1987), who advocate for allocating goods in a manner that maximizes benefits for the greatest number of people. This approach prioritizes the overall well-being and utility of society as a whole.

However, what has been repeatedly observed is that the ability to present information to decision-makers impacts the final evaluation of fairness. This phenomenon, initially termed the *process control effect* (Thibaut & Walker, 1975) and later referred to as the *voice effect* (Folger, 1977), stands as one of the most extensively studied phenomena in *procedural fairness* research. Numerous studies have consistently validated this phenomenon, demonstrating that the opportunity for individuals to voice their concerns or opinions has a substantial influence on judgments of fairness (e. g. Kanfer, Sawyer, Earley, & Lind, 1987; Lind et al., 1980). Crucially, Leventhal (1980) outlined key elements in the justice judgment model, particularly emphasizing the formulation of procedural rules or fairness criteria. According to Leventhal (1980) allocation procedures are perceived as fairer when processes are based on *representativeness*, i.e. that all affected persons are represented in the decision-making process, *consistency*, i.e. that decisions are the same for all persons and at all times, *bias suppression*,

i.e. that no factors distort the decision-making process, and *correctability*, i.e. that there are possibilities to correct erroneous decisions. In general, all decision-making processes should be based on fundamental *ethical* standards.

In further research on procedural fairness, Bies and Moag (1986) identified that it is not solely a matter of the procedures themselves but also how these procedures are enacted. Their research on *interactional fairness* revealed that the propriety of the decision-makers plays a decisive role in how fairness is ultimately evaluated. They discovered that whether and how decisions are communicated to those affected plays an integral part of how individuals evaluate the fairness of outcomes. When there is an adequate explanation and decisions are justified, the ultimate fairness judgment is higher. According to Bies and Moag (1986), people are particularly sensitive to interpersonal communication during decision-making and expect honesty and respect. They conclude "what one says about the enactment of a procedure can be as important as what one does when he or she enacts the procedure" (Bies & Shapiro, 1987, p. 216).

Bies and Moag (1986) focused on aspects of communication during the decision-making processes and identified *truthfulness, respect, propriety* and *justification* as central elements of interactional fairness. The significance of providing explanations for decisions has been substantiated in multiple studies. When explanations are offered, it tends to enhance the final fairness assessment, increase acceptance of decisions, and reduce feelings of anger (Bies & Shapiro, 1987, 1988; Bies, Shapiro, & Cummings, 1988; Bobocel & Zdaniuk, 2013; Shaw, Wild, & Colquitt, 2003).

In a more progressive approach, Greenberg (1993) introduced a model of fairness that distinguishes between procedural fairness as the non-social component and interactional fairness as the social component of a process. This distinction between social and non-social should also apply to the distribution process. In sum, Greenberg (1993) proposes a conceptualization of fairness into social and non-social for distributive and procedural fairness, leading to a four-component model. Procedural and distributive fairness, thus, describe the mechanisms which are non-social and informational and interpersonal fairness, describe the social component of a procedure, and the social component of outcome distribution.

For many decades, debates have persisted regarding whether interactional fairness can genuinely be regarded as an independent facet of fairness or whether it should be considered a component of procedural fairness. These discussions also encompass broader questions about the scope of how procedural fairness should be conceptualized in general, as exemplified by the work of Bies (2001).

In the following, I will adopt a conceptualization of fairness based on the four facets proposed by Greenberg (1993): *distributive*, *procedural*, *informational*, and *interpersonal* fairness. Additional research conducted by Colquitt (2001) delved into the dimensional aspects of fairness. The outcomes of his confirmatory factor analysis underscore the division into these four distinct and separate facets of fairness, as illustrated in Table 1.

Table 1. The Four Facets of Fairness

Type	Name	Description
Distributive	Equity	Outcomes are allocated according to contributions
	Equality	Outcomes are allocated equally
	Need	Outcomes are allocated according to need
Procedural	Process Control	Procedures provide opportunities for voice
	Decision Control	Procedures provide influence over outcomes
	Consistency	Procedures are consistent across persons and time
	Bias Suppression	Procedures are neutral and unbiased
	Accuracy	Procedures are based on accurate information
	Correctability	Procedures offer opportunities for appeals of outcomes
	Representativeness	Procedures take into account concerns of subgroups
	Ethicality	Procedures uphold standards of morality
Informational	Truthfulness	Explanations about procedures are honest
	Justification	Explanations about procedures are thorough
Interpersonal	Respect	Enactment of procedures are sincere and polite
	Propriety	Enactment of procedures refrain from improper remarks

Note. Rules for distributive fairness taken from Adams (1965); Leventhal (1980), rules for procedural fairness taken from Leventhal (1980); Thibaut and Walker (1975), rules for informational and interpersonal fairness taken from (Bies & Moag, 1986; Greenberg, 1993), inspired by Colquitt and Rodell (2015).

So far, the most prominent theories concerning individuals' perception of fairness have been described. In the following, the underlying processes that explain why people care about fairness in the first place will be explored. While theories mentioned so far have focused on what fairness is, it is essential to shift our attention to why humans perceive fairness and how they respond to it.

To understand why having a voice has such a significant impact on the final judgment of fairness, numerous studies and theories have been developed to shed light on this issue. Some of these theories relate the impact of the voice to instrumental consequences. At best, having a voice means influencing the outcome of decisions and gaining an advantage. In the instrumental theories, voice is mainly important to achieve a favorable (Colquitt & Rodell, 2015; Leventhal, 1980) or an equitable outcome (Thibaut & Walker, 1978).

Another stream of research endeavors to link the phenomenon to more symbolic and non-instrumental implications. In Lind & Tyler's *Group Value Model* (1988), the effect of voice is explained by the implicit message it conveys: a sense of belonging to a group. This extends the earlier perspective that individuals are primarily concerned with maximizing their own outcomes. Having a voice implies group membership and signifies that one's opinions are worthy of consideration (Lind & Tyler, 1988). This perspective ties in with *Social Identity Theory* (Tajfel & Turner, 1978), emphasizing the importance of one's group status and social identity in determining their sense of self-worth. In their further expansion of the Group Value Model, the *Relational Model of Authority*, Tyler and Lind (1992) suggest that a middle ground probably provides the best explanation of the voice effect, i.e. it is about, not only being able to control the outcome of decisions but also group membership.

Moreover, in research exploring the non-instrumental effects of procedural justice, De Cremer and Blader (2006) could demonstrate that the effects of voice were stronger in people with a high need for belonging, than for people with low belongingness needs. Additionally, a study by De Cremer, Brockner, van den Bos, and Chen (2005), aligned with the prediction of the Relational Model by showing that procedural fairness has a stronger effect on cooperation and positive affect when individuals have a strong interdependent self-construal.

Another approach towards explaining why people respond so strongly to procedural fairness is the *Fairness Heuristic Theory* (Lind, 2001; Lind, Kulik, Ambrose, & de Vera Park, 1993). This theory posits that procedural fairness serves to reduce uncertainty, a critical factor in social interactions where individuals need to quickly assess trustworthiness. According to the Fairness Heuristic Theory, procedural fairness provides a heuristic process for deciding whether another person can be trusted. Evaluating fairness based on Adams' (1965) comparison

principle would require information about what others receive, which may not always be available. In such cases, people rely on procedural fairness as a substitute for determining the fairness of the outcome. This theory suggests that when individuals are uncertain about the trustworthiness of authorities, they react more strongly to procedural fairness (van den Bos, van Schie, & Colenberg, 2002; van den Bos, Wilke, & Lind, 1998). This also implies that people are influenced more by distributive fairness, if information about procedural fairness is missing (van den Bos et al., 1997a). Individuals will use whatever information is available to judge the trustworthiness of their interaction partner, to reduce uncertainty in social interaction (Jones & Skarlicki, 2005). In their expanded theory, labeled *Uncertainty Theory* (van den Bos & Lind, 2002), people are seen to resolve uncertainty in broader terms, not limited to trust in authorities. When individuals are reminded of aspects in their lives that generate uncertainty (e.g. their own mortality), the effects of procedural justice tend to be most pronounced (van den Bos, 2001; van den Bos & Miedema, 2000).

In the *Fairness Theory* by Folger and Cropanzano (2001), the aspect of accountability plays a more central role. In this theory, when an individual detects unfair treatment, they hold someone accountable for actions that threaten another person's well-being, either materially or psychologically. If no one is to blame, then there is no social injustice (Folger & Cropanzano, 2001). According to Fairness Theory, both procedural fairness and interactional fairness can mitigate the negative impact of low distributive fairness because they reduce the accountability of authorities. In the Fairness Theory (Folger & Cropanzano, 2001), the attribution of responsibility is a central element, rather than the violation of procedural or interactional fairness.

To summarize, these efforts explain why individuals are concerned with fairness, Bobocel and Gosse (2015) argue that it depends on the situation and that these theories are complementary rather than competing. This suggests that there may be multiple reasons why individuals are concerned with fairness, and the concerns may be influenced by the specific context. In some situations, people may be primarily concerned with the outcome, while in others, the motivations may be more relational, driven by a sense of belonging or social identity (Bobocel & Gosse, 2015).

The positive impacts of perceived fairness are numerous and include among others: greater satisfaction with decisions and outcomes (Greenberg, 2000), maintaining a more positive affect and more inclined to cooperate (Lind, 2001; Weiss, Suckow, & Cropanzano, 1999), more positive evaluations of pay (Tyler, 2000; van den Bos et al., 1997a), job satisfaction, trust in management (Alexander & Ruderman, 1987), organizational commitment,

job performance (Colquitt et al., 2001), and more positive attitudes toward judges and the court (Tyler, 1984). van den Bos (2018) linked perceived unfairness to the radicalization and development of extremist behavior.

This section underscores the significant role that (un)fairness plays for individuals and especially in social interactions. Coming back to the statement "YOU expose ME" (van Gunsteren, 1999), which summarizes the relationship between residents affected by aircraft noise and the airport, it becomes clear that fairness may play a very central role in this context.

As Maris (2008) has suggested, experiencing aircraft noise can be viewed as a form of social interaction. Those residents who are affected by noise may attribute responsibility to the airport for the disturbances they endure. The noise itself is a direct result of decisions made by individuals, institutions, or groups of people. This attribution of responsibility is a fundamental element in the context of fairness conflicts (Folger & Cropanzano, 2001).

Aircraft noise has tangible consequences for the individuals who experience it. People affected by aircraft noise may feel restricted in their own personal freedom, for example by not being able to enjoy their time in the garden or being interrupted in their conversations because of the noise. Furthermore, people may also feel limited in their freedom because they have to close their windows at night due to the noise, which leads to a higher level of annoyance and dissatisfaction with the indoor climate despite noise reduction (Schreckenber, 2012). Moreover, there can be financial repercussions, such as a reduction in property values when aircraft frequently fly overhead (Nelson, 2004; Trojanek & Huderek-Glapska, 2018).

From the perspective of psychological fairness research, the reactions of annoyance, negative attitudes toward the airport or air traffic, and sometimes even intense protests can be understood as manifestations of *perceived injustice*. This underscores the intricate connection between fairness considerations and the experiences of those affected by aircraft noise.

Expanding aircraft noise research by incorporating the extensive insights from fairness psychology holds the promise of achieving a deeper comprehension of reactions like annoyance, acceptance, and the willingness to engage in protest. Furthermore, this knowledge can be instrumental in actively fostering a sense of fairness within this context.

By applying the findings from fairness psychology, it becomes conceivable to cultivate a more positive relationship between the airport and the residents who experience aircraft noise. This improved relationship has the potential to yield long-term benefits, notably enhancing the quality of life for affected individuals.

Additionally, leveraging the insights from social justice research may lead to more effective interventions by the airport, aimed at improving their relationship with residents

impacted by aircraft noise. This, in turn, can contribute to more successful efforts in mitigating the negative effects of noise disturbances and fostering a more harmonious coexistence between airports and their surrounding communities.

3. Gaps in Research on Fairness in the Context of Aircraft Noise

Beginning with the recognition that the distribution of aircraft noise is intertwined with aspects of *fairness*, several, up to now, unresolved questions come to the forefront. As Maris (2008) suggested, experiencing aircraft noise can be understood as a form of social interaction, wherein affected residents attribute responsibility to the airport for the noise they endure—a critical element in fairness conflicts (Folger & Cropanzano, 2001). It is about gaining a deeper understanding of annoyance from a socio-psychological perspective. Based on the lack of, or insufficient research in this area, four shortcomings have been identified. These are (1) conceptual gap, (2) lack of qualitative research, (3) a missing measurement tool and lastly, (4) empirical evidence on the effects of fairness, in the context of aircraft noise research.

3.1 Conceptual Gap

In previous research on factors impacting the annoyance due to aircraft noise, aspects such as trust in noise authorities, predictability of future noise events or the involvement of citizens in decision-making processes at the airport were discussed (e.g. Bartels et al., 2022; Guski, 1999). A number of these non-acoustic factors are tied to the concept of fairness, and therefore, their explanation lies within the realm of research in this area. What has been lacking in the discourse about these non-acoustic factors is a *theoretical foundation* that underpins such factors.

Fairness as a construct has been an integral part of organizational psychology and the judicial context for many decades (for an overview, see Colquitt et al., 2001). In the context of aircraft noise research, however, fairness as an underlying construct was mentioned only to a very limited extent.

Procedural fairness has been studied in the laboratory (Maris et al., 2007b) and it has been shown that the perception of voice and procedural control results in a reduction of perceived annoyance. Additionally, in a survey conducted among residents impacted by aircraft noise, it was discovered that those who believe that affected residents are included in the airport's decision-making processes experience less annoyance (Jue, Shumaker, & Evans, 1984). Moreover, in hypothetical airport expansion scenarios, the situation is perceived as more socially acceptable when a variety of participation opportunities are offered (Liebe et al., 2020). Finally, in a field study Schreckenberget al. (2017b) found that there are considerable differences in annoyance ratings when affected residents perceive procedural fairness.

By employing the multidimensional concept of fairness to the context of aircraft noise research in more depth, we can not only better explain the behavior of frustrated and upset

residents, but also provide empirical evidence for developing management strategies to enhance the fairness among residents. This, in turn, can help to manage residents' annoyance and negative attitude towards the airport.

At present, a large number of interventions initiated by the airport with the aim of improving public perception and relationships with affected residents lack a solid theoretical foundation. As a result, these interventions often fail to achieve their intended results, sometimes even exacerbating negative attitudes towards the airport among residents (Porter, 2017; Schreckenberg, 2012; Schreckenberg, Mohler, Liepert, & Schuemer, 2013; Suau-Sanchez, Pallares-Barbera, & Paül, 2011). Based on these observations, the following research questions emerge:

RQ1: To what extent can fairness theories contribute to a deeper understanding of annoyance reactions due to aircraft noise?

RQ2: What opportunities emerge from the conceptualization of aircraft noise as a fairness dilemma in regards to mitigating annoyance reactions and protest behavior against the airport, and to enhance the acceptance of the airport and air traffic?

3.2 Lack of Qualitative Research

Conducting qualitative research is essential to gain a comprehensive understanding of the concept of fairness in all its dimensions in the context of aircraft noise research. While previous qualitative research has demonstrated the significant influence of residents' attitudes towards the airport on annoyance and their desire for neighborly behavior such as improved communication and more information (Sommerfeld, 2013), to the best of the authors' knowledge the aspect of fairness has not been thoroughly explored in qualitative studies. It remains uncertain if the classification into the four facets of fairness - distributive, procedural, informational and interpersonal fairness - is also appropriate in the context of aircraft noise research and whether there are specific characteristics that differ in comparison to the research field of organizational and judicial psychology. By involving residents affected by aircraft noise, it becomes feasible to investigate whether and to what extent the four fairness facets are relevant and whether there might be aspects that are particularly significant in this context of aircraft noise research. Previous research in this context has not yet systematically examined the perspectives of residents affected by aircraft noise with the aim of assessing the dimensionality and relevance of fairness. This leads to the following research question:

RQ3: To what extent can statements made by residents affected by aircraft noise be attributed to the four fairness facets and their subfacets?

RQ4: Are there aspects of fairness that are more or less relevant in the context of aircraft noise research?

3.3 Missing Measurement Tool

Up to now, interventions by the airport aimed at improving the relationship with noise affected residents and fostering a neighborly atmosphere have only been evaluated to a very small extent (Heyes et al., 2022). One reason for this is a lack of measurement instruments that can capture residents' perceptions of the airport in a valid and reliable way. Initially, an attempt was made to create a questionnaire in a previous endeavor by Bartels (2014). However, this initial approach relied solely on literature and was tested with a limited number of subjects in a field study. Consequently, there is a need to develop and validate a multidimensional questionnaire within the framework of a large-scale study involving a substantial number of participants. Developing a psychometric instrument would provide the advantage of addressing existing gaps in both research and practical applications. By comprehensively assessing fairness, it can enhance our understanding of the origins and persistence of annoyance, and, thus, shed light on previously unexplained variance of noise annoyance. Additionally, it may illuminate the importance of fairness in the complex interdependencies contributing to conflicts between residents and airports, often resulting in protests and petitions against the airport. This deeper insight could also provide a clearer understanding of the factors influencing the airport's acceptance as a neighbor within the region.

Practically, such a measurement tool would facilitate targeted and efficient interventions aimed at enhancing neighborly relations between the airport and residents. For instance, airports could employ the questionnaire before interventions to gather current perceptions of citizens, pinpoint aspects requiring improvement, and subsequently make these aspects the focus of interventions. Furthermore, a questionnaire would facilitate continuous monitoring of interventions, thus, making it possible to assess the status of success of these interventions accurately at any point in time. Currently, airports invest a considerable amount of money in interventions without a specific evaluation strategy (Heyes et al., 2022). Introducing a questionnaire can bridge this gap by offering an empirical assessment method, advancing research in this area. Therefore, the question arises:

RQ5: How can fairness be measured as a multidimensional construct in the context of aircraft noise?

3.4 Empirical Evidence on the Dimensionality and the Effects of Fairness

Creating such a measurement tool of fairness within the framework of aircraft noise research could provide insights into additional research queries. At present, it remains unclear whether the classification into four fairness facets - distributive, procedural, informational and interpersonal fairness - which is the current state of knowledge in organizational psychology (Colquitt, 2001), is really appropriate within the present context. It could be assumed that a classification of fairness in other configurations, such as a three- or two-factor solution might make more sense. Since data must be collected in developing such a questionnaire, it becomes possible to assess its dimensional structure.

Another research question, closely tied to the measurement of fairness, revolves around empirically exploring pertinent relationships. As demonstrated in the introduction, these aspects may be interconnected and stem from perceptions of (un)fairness. Therefore, the inquiry that emerges is the extent to which fairness correlates with other factors relevant in aircraft noise research, including noise annoyance, acceptance of the airport, and a general tendency for protest. By examining these interconnections, we can gain a more profound understanding of the significance of fairness and determine whether the hypothesized connections indeed manifest in real-world scenarios. Therefore, the research questions are:

RQ6: How should the dimensionality of fairness be assessed in the context of aircraft noise research?

RQ7: What is the connection between fairness and relevant predictor variables?

4. Overview of Research Articles

The present dissertation comprises three research articles aimed at addressing the research questions at hand. These articles collectively explore the concept of fairness within the domain of aircraft noise research, offering a comprehensive perspective on the subject. The logical structure of these papers allows for a progressive development of ideas.

The first research article employs a narrative review approach to analyze aircraft noise from the standpoint of social justice research. Within this framework, the review applies the facets of fairness—namely, distributive fairness, procedural fairness, informational fairness, and interpersonal fairness—derived from research conducted in other fields such as organizational or judicial psychology. The relevance of these fairness facets in the context of aircraft noise research is assessed (RQ1), providing a summary of the existing efforts and potential avenues for improvement at airports. This literature review highlights the untapped potential of fairness for sustainable airport management, while also highlighting the scarcity of current research in this area (RQ2).

The second article builds upon the insights gained from the first paper and aims to provide an additional perspective on fairness research by involving residents affected by aircraft noise. Specifically, the study conducts a qualitative examination of the four fairness facets introduced in the initial article. To achieve this, focus group discussions and in-depth interviews with individuals residing near Cologne-Bonn Airport, Dusseldorf Airport and Paris-Charles-de-Gaulle Airport who experience varying levels of aircraft noise are surveyed. Through a qualitative content analysis, the study investigates the extent to which affected residents mention fairness aspects and identify specific characteristics associated with these facets (RQ3). Given that prior fairness research has primarily been conducted in different contexts, the active involvement of residents is crucial to obtain a deeper understanding of the significance of fairness (RQ4). Based on findings, the study formulates recommendations for airports, aiming to incorporate the desires, suggestions, and concerns of affected residents into airport management practices.

In the third research article, the insights derived from the first two papers are utilized to develop and validate a questionnaire designed to capture fairness perceptions of residents regarding the airport management (RQ5). This process involves several steps. First, a pool of potential questionnaire items, encompassing the four fairness facets, is being developed on the basis of a literature review, from the perspective of noise affected residents and through the consultation of experts in this field, like researchers, noise protection managers and airport

authorities. Secondly, a large-scale cross-sectional online study is conducted, involving a substantial number of residents ($N = 1,367$) residing near Cologne-Bonn Airport, Düsseldorf Airport, and Dortmund Airport. Thirdly, suitable items are selected, and the dimensional structure of the four fairness facets is determined (RQ6). Furthermore, the instrument's reliability and validity are assessed, contributing to its overall evaluation. Finally, the correlation between the four fairness facets and relevant outcome variables such as annoyance due to aircraft noise, acceptance of the airport and air traffic and willingness to protest is surveyed in order to emphasize the empirical relevance of fairness in the present context (RQ7).

In summary, this dissertation presents a comprehensive exploration of fairness within the field of aircraft noise through three distinct research articles, collectively contributing to a holistic understanding of the potential and effects of fairness. The logical progression of ideas and the integration of findings from the initial review, qualitative examination, and questionnaire development and validation enable a cohesive and rigorous examination of fairness, shedding light on its significance for sustainable airport management practices, resulting in a higher quality of life of residents living around airports.

This dissertation, which is part of the EU project Aviation Noise Impact Management through Novel Approaches (ANIMA, Grant Agreement No. 769627), is based on three scientific papers, which have either been accepted for publication or submitted to a journal with peer-review procedure. The thesis was written in collaboration and with the help of other researchers and colleagues. In the following, I would like to briefly describe the contribution of my colleagues to this thesis.

I, as the author of this dissertation, was responsible for the development of each of the research articles, conducting the studies, collecting and analyzing data, as well as writing the research articles presented within this work. Initially, Uwe Müller from the German Aerospace Center served as the primary supervisor, providing guidance and funding for all studies through the EU-project ANIMA. Susanne Bartels from the German Aerospace Center supervised the PhD process, offering valuable advice and feedback on various aspects such as paper writing, manuscript drafts, data collection, and analysis of all research articles. She is also co-author of all three research articles. Tobias Rothmund from the Friedrich-Schiller-Universität Jena, a co-author of all three papers supervised the PhD process and contributed by providing valuable advice and feedback on paper ideas, manuscript drafts, data collection and analysis. Dirk Schreckenber from the ZEUS GmbH (Zentrum für angewandte Psychologie, Umwelt- und Sozialforschung), also being a co-author of all the three research articles assisted by giving feedback on all manuscript drafts and helping with the data analysis of the in-depth interviews

around Dusseldorf Airport of research article two (Chapter 6). Julia Quehl from the German Aerospace Center assisted as a facilitator during the conduction of the focus group discussions in research article 2 (Chapter 6).

Julia Kuhlmann (ZEUS GmbH), Isabelle Richard and Camille Emanuely from Environnons helped with the data collection and analysis of the in-depth interviews around Dusseldorf Airport and the focus group discussions around Paris-Charles-de-Gaulle Airport as well as manuscript drafts of research article 2 (Chapter 6). Marie-Therese Schmitz from the German Aerospace Center assisted with the data analysis of research article three (Chapter 7). A summary of the three research articles, including their focus, research questions, and publication status, is provided in Table 2.

Table 2. Overview of the Three Research Articles

No.	Title and Authorship	Paper Focus and Relevant Research Questions	Publication Status
Article I:	Aircraft Noise Distribution as a Fairness Dilemma—A Review of Aircraft Noise through the Lens of Social Justice Research First Author	<u>Creating a Theoretical Framework:</u> <ul style="list-style-type: none"> • Defining the distribution of aircraft noise as a fairness dilemma • Drawing from fairness research of other domains (RQ1) • Conceptualize fairness as four dimensions • Identify ways to improve the perception of fairness (RQ2) 	Published in the <i>International Journal of Environmental Research and Public Health (IJERPH)</i>
Article II:	“The Airport does what it wants to do anyway.” What Constitutes a Fair Relationship with the Airport from the Perspective of Airport Residents? – A Qualitative Study Approach First Author	<u>Researching Fairness from the Perspective of Residents:</u> <ul style="list-style-type: none"> • Conducting focus group discussions and in-depth interviews with noise affected residents • Classification of statements into the four fairness facets (RQ3) • Highlighting of characteristics and special features of fairness (RQ4) • Developing of a guideline for the integration of fairness aspects into airport management 	Submitted to <i>Transportation Research Interdisciplinary Perspectives (TRIP)</i>
Article III:	Being a Fair Neighbor—Towards a Psychometric Inventory to Assess Fairness-Related Perceptions of Airports by Residents— Development and Validation of the Aircraft Noise-Related Fairness Inventory (fAIR-In) First Author	<u>Development and Validation of a new Instrument to Measure Fairness in the Context of Aircraft Noise Research:</u> <ul style="list-style-type: none"> • Development of items through literature, focus groups and expert interviews • Assessing psychometric properties of the scale (RQ5) • Measuring and comparing the model fit of the classification into the four fairness facets to other structures (RQ6) • Analyzing the correlation between fairness and relevant outcome variables (RQ7) 	Published in the <i>International Journal of Environmental Research and Public Health (IJERPH)</i>

Note. Own table based on own work.

5. Aircraft Noise Distribution as a Fairness Dilemma—A Review of Aircraft Noise through the Lens of Social Justice Research²

Abstract: Aircraft noise exposure is a health risk and there is evidence that noise annoyance partly mediates the association between noise exposure and stress-related health risks. Thus, approaches to reduce annoyance may be beneficial for health. Annoyance is influenced by manifold non-acoustic factors and perceiving a fair and trustful relationship between the airport and its residents may be one of them. The distribution of aircraft noise exposure can be regarded as a fairness dilemma: while residents living near an airport may seem to have some advantages, the majority of residents living under certain flight routes or in their immediate proximity suffer from the disadvantages of the airport, especially the noise. Moreover, a dilemma exists between the airport's beneficial economic impact for a region and the physical and psychological integrity of residents. Aircraft noise exposure through the lens of social justice research can help to improve our understanding of noise annoyance. Research indicates that the fairness perceptions of the parties involved can be enhanced by (a) improving individual cost–benefit ratios, (b) providing a fair procedure for deciding upon the noise distribution, and (c) implementing fair social interaction with residents. Based on the review of evidence from social justice research, we derive recommendations on how fairness aspects can be integrated into aircraft noise management with the purpose of improving the relationship between the airport and its residents, to reduce annoyance, and to enhance the acceptance of local aviation and the airport as a neighbor.

5.1 Introduction

Exposure to aircraft noise has been associated with a variety of different adverse health outcomes (Ancona et al., 2014). These range from annoyance due to noise (Bartels, 2014; Guski et al., 2017; Miedema & Oudshoorn, 2001; Nguyen et al., 2018; Raimi & Adindu, 2019), sleep disturbance during the night (Bartels et al., 2019; Basner & McGuire, 2018; Elmenhorst, Griefahn, Rolny, & Basner, 2019; McGuire, Müller, Elmenhorst, & Basner, 2016; Muzet,

² This article was authored by Dominik Hauptvogel, Susanne Bartels, Dirk Schreckenberger and Tobias Rothmund and has been published on July 11th 2021 in the International Journal of Environmental Research and Public Health. Link: <https://doi.org/10.3390/ijerph18147399>

2007), associations with cardiovascular diseases (van Kempen et al., 2018), myocardial infarction (Babisch et al., 2005), coronary heart disease (Roca-Barceló et al., 2021), and blood pressure (Dratva et al., 2012). The harmful effect of noise has already been demonstrated for infants and children, on health, perception, and learning, e.g., through the deterioration of reading and oral comprehension in school children (Erickson & Newman, 2017; Klatte et al., 2013; Klatte et al., 2017; Zacarías, Molina, Ancela, López, & Ojembarrena, 2013).

Annoyance due to noise is widespread in airport communities and occurs even at relatively low noise levels (Guski et al., 2017). The concept of annoyance is multi-dimensional and comprises cognitive, emotional, and behavioral aspects (Guski et al., 2017). Annoyance is not only regarded as a primary adverse effect of aircraft noise, but is assumed to be part of the causal pathway of other health outcomes and thus seems to mediate the effect of aircraft noise exposure and health risks (Brown & van Kamp, 2017). Studies suggest that people reporting high levels of annoyance to have a higher risk for hypertension (Babisch et al., 2013; Baudin et al., 2020; Eriksson et al., 2010), a decrease in reported physical well-being (Spilski, Bergström, Möhler, Lachmann, & Klatte, 2019), higher psychological distress (Baudin et al., 2018), and, finally, an association was found between noise annoyance and the use of medication to treat anxiety disorders (Baudin et al., 2021). In addition, noise annoyance was observed to have an effect on sleep quality (Bartels, 2014) and physical activity (Foraster et al., 2016). In other studies, aircraft noise did not have a direct effect on factors related to mental-health-related quality of life (Schreckenberg et al., 2017a) or diagnoses of depression (Benz & Schreckenberg, 2019), but an indirect effect via annoyance was found. That means that the absolute noise exposure per se does not directly decrease mental health-related quality of life or diagnoses of depression, but perceiving annoyance does. Regarding mental health, one study revealed that the noise profile around an airport could have an effect, indicating that, for example, bigger airports with more flights including night flights affect mental health to a larger extent than noise profiles from smaller airports (Wright, Newell, Maguire, & O'Reilly, 2018). Furthermore, it was found that the degree of changes in noise exposure at airports also lead directly to a poorer mental health-related quality of life (Schreckenberg et al., 2017a). This indicates that situations of change (e.g., an expansion of an airport) are especially critical.

The mediating effect of annoyance on other health aspects can be explained by acknowledging that annoyance is a stress response. The sounds of aircraft only become noise when they are subjected to a certain evaluation. Aircraft noise can cause disturbance when trying to concentrate, for example. Therefore, aircraft noise, or any other environmental noise, can be seen as a stress factor (Bodenmann & Gmelch, 2009). In evolutionary terms, stress is a

reaction necessary for survival that is triggered when we are faced with a dangerous situation, such as a wild animal. In modern times, however, these stress reactions are rarely triggered by life-threatening events. Nevertheless, in the human body, stress triggers reactions such as the release of cortisol or a change in blood pressure, which can have long-term health consequences (Babisch, 2002). However, the evaluation of a sound as noise is highly subjective and depends on a variety of non-acoustic factors, such as attitudes, expectations, and situational and personal factors (Bartels, Rooney, & Müller, 2018). Psychological models of noise reactions such as the model proposed by Stallen (Stallen, 1999) suggest that the stress reaction, here the degree of annoyance, also depends on the possibility to cope with and control the stressor. Whether an individual perceives the ability to control the noise and the capacity to cope with it likewise depends on non-acoustic factors such as experienced trust in the authorities of the noise source, the predictability of the noise occurrence, influence on the noise source and access to information (Stallen, 1999).

A major psychological construct implicitly underlying these non-acoustic factors is social (in)justice or (un)fairness (the two terms are used interchangeably throughout the manuscript). This construct has been extensively examined in the organizational and justice context with regard to the acceptance of outcomes of social exchange. In the present paper, the distribution of aircraft noise exposure and the relation between the noise source (i.e., the airport management) and the noise-affected individuals are reviewed from the perspective of fairness research, and it is thus considered to be a fairness dilemma. By adopting this perspective, the paper derives approaches for the reduction of adverse responses to noise by enhancing the perceived capacity to cope with noise in the affected individuals.

The construction or expansion of an airport often induces fears concerning the impairment of quality of life in many airport residents. European examples include the opening of the fourth runway at Frankfurt Airport, Germany, in 2011; the planned expansion of Heathrow Airport, UK, in 2026; and Florence Airport in 2029 (BBC, 2019; Larinni, 2020), or the planned construction of a new terminal in Paris-Charles-de-Gaulle in 2021 (Handelskammer, 2019). An expansion, such as a new terminal or runway, usually comes along with an increase in flight movements, or at least a reshuffling of departures and/or approach routes and, thus, a redistribution of the noise. As a result, some residents will experience an increase in noise exposure. Thus, conflicts between the airport or airport stakeholders and the residents, as well as between residents from different communities, are predominantly connected to a shift of noise exposure.

As aircraft noise, unlike other types of noise (such as natural sounds), is caused by humans, it can be seen as a kind of social exchange (Maris et al., 2007a; van Gunsteren, 1999). Individuals (in this case (airport) operators) can be seen as responsible for the noise residents have to bear. The noise from aircraft can therefore be seen as a constant reminder of unfair treatment (Maris et al., 2007a). While there seem to be some advantages, for example, easy access to travel or potential employment opportunities for residents living around the airport, residents living under air corridors have to bear the noise with all its ramifications described above, as well as other costs, i.e., the loss of property value (Batóg, Foryś, Gaca, Głuszak, & Konowalczyk, 2019; Trojanek & Huderek-Glupska, 2018; Zheng, Peng, & Hu, 2020). The uneven spread of noise in proximity to an airport area can be seen as a fairness dilemma: the noise has to be shouldered by one group, and the potential advantages of the airport are shared by others. Therefore, the ratio between the benefits and drawbacks of the nearby airport varies considerably between residents. Importantly, residents perceive having little control over the decision of how the burden of noise is distributed. Rothmund et al. (2014) point out that the feeling of injustice can trigger strong emotional reactions and is therefore a motivational source for political protest and opposition, explaining the sometimes outraged and protesting residents living around the airport.

The present paper is addressed to noise researchers, airport authorities, and policymakers and pursues two general goals. First, we aim to illuminate the fairness dilemma of aircraft noise exposure using the psychological perspective of social justice research. In order to better understand the psychological underpinnings of how individuals deal with the fairness dilemma regarding noise exposure, empirical research on the psychology of social justice offers some valuable insights. Social justice research distinguishes between different forms of fairness, namely, distributional fairness, procedural fairness, and informational or interactional fairness. All three conceptualizations provide unique and illustrative approaches that can inform the understanding of how unfairness is perceived in the context of noise distribution. However, insights from social justice research cannot only be used to better describe and explain the behavior of angry and annoyed residents, which is often expressed in complaints and protest (Rothmund et al., 2014). They also provide empirically based starting points for developing communicative interventions in order to enhance the residents' perceived fairness of the noise distribution and, thus, to manage the acceptance of the airport as a neighbor, noise annoyance, and the burden of some residents from an intervention perspective. Our second goal is to emphasize and review possible ways to resolve, or at least handle, the emotional and attitudinal consequences of noise distributions that are perceived as unfair. The paper concludes by

developing recommendations of how airports can implement these fairness psychological findings in practical terms.

5.2 Distributive Fairness

In this section, we outline and discuss theoretical explanations for why and how the distribution of aircraft noise is perceived as a fairness issue. We present empirical research and derive intervention strategies.

5.2.1 *What Is a Fair Noise Distribution?*

As argued before, aircraft noise annoyance can result from a social conflict over distributional fairness. However, we also consider when and how individuals perceive distributions to be unfair. Equity theory (Adams, 1965) and relative deprivation theory (Runciman & Runciman, 1966) provide similar answers to this question.

Both approaches emphasize that humans evaluate fairness based on social comparisons of cost–benefit ratios. According to equity theory (Adams, 1965), distributive fairness or equity is experienced when the cost–benefit ratios between individuals are perceived as equivalent. Contrarily, when inequality between these ratios is perceived, individuals tend to feel that they are being treated unfairly. In a similar vein, relative deprivation theory posits that anger and rumination are triggered when individuals perceive themselves to be deprived relative to what they expect to deserve or relative to what significant others receive (for an overview, see (Smith et al., 2012)).

Leventhal (1980) extended these lines of research by showing that individuals evaluate deservingness and fairness based on different principles. Besides the equity rule as described above, he also suggests the equality and the need rule. The equality rule suggests that any costs or benefits should be distributed equally among all those people that are eligible. The needs rule takes into consideration the vulnerability of individuals. It suggests that vulnerable people (such as children, sick or old people) should be less exposed to costs or burdens and benefit more easily than healthy adults. A further type of distribution principle is based on Bentham’s utilitarianism (Mill & Bentham, 1987), according to which costs or benefits should be distributed in such a way that the greatest possible overall benefit would be generated.

Summarizing these different principles, noise could be distributed in several ways:

1. The aircraft noise is distributed in a way that the ratio between the disadvantages (i.e., the burden of the noise exposure) and the benefits of the nearby airport are equal between all residents (equity rule/contribution rule);

2. Noise should be distributed equally over as many residents as possible, regardless of the composition of residents and other environmental strains (equality rule);
3. Residents with special needs (e.g., children, sick or elderly) should be protected from the noise as much as possible (needs rule);
4. Noise should be distributed in such a way that the highest number of residents will be protected from noise, even if some residents will experience very high levels of noise (utilitarianism approach).

Unfortunately, no answer can be given at present to the question of which of the presented principles of distribution of aircraft noise should now be implemented in order to achieve the fairest perception of aircraft noise. In a preliminary study (Liebe et al., 2020), no significant effect of the different allocation principles on the perceived fairness was found. However, future research should address this issue. An example of how noise distribution is technically modifiable can be shown in a statistical evaluation of flight operational characteristics that points out that by reorganizing the departure direction and/or departure performance restrictions, noise could be distributed in order to minimize the noise impact in certain areas (Gagliardi, Teti, & Licitra, 2018). New technologies, such as the automatic dependent surveillance-broadcast (ADS-B) may be beneficial by providing more accurate data than conventional radar systems on, e.g., take-off ground run distance and altitude data (Gagliardi, Fredianelli, Simonetti, & Licitra, 2017).

Individuals differ in their fairness evaluations not only because they rely on different fairness principles but also because they differ in their general sensitivity to perceiving and experiencing unfairness (Schmitt, Baumert, Gollwitzer, & Maes, 2010a). Based on these findings, some people experience stronger emotional reactions to injustice (i.e., anger and outrage) and are more likely to ruminate on perceived unfairness. These individual differences can partly explain why some people are more engaged in political protest and opposition towards large public transport projects (Rothmund et al., 2014).

This research on distributional fairness consequently suggests two different strategies for interventions to minimize perceived unfairness in the distribution of airport noise. The first strategy is to implement the fairness principle that is most likely to be perceived as fair by a respective group of residents. The second strategy is to compensate individuals who are disadvantaged by a specific noise distribution so that their ratio between costs and benefits improves.

5.2.2 Finding the Balance—Compensation to Amend for an Unfair Distribution?

A cost–benefit balance can either be achieved by reducing the cost (i.e., the individual noise level) or by increasing the benefit of individuals who are affected by aircraft noise. The following interventions focus mainly on the reduction of individual costs. However, potential interventions increasing the individual benefits will also be discussed as these have not yet been implemented.

5.2.3 Noise Insulation

Noise insulation and other abatement measures at home (i.e., insulation of the wall, soundproof windows with or without a ventilation system) can drastically reduce indoor sound levels, potentially reducing noise. A telephone survey in 2010 with citizens in proximity to Frankfurt Airport revealed that a large proportion of the residents do not claim insulation entitlement, and, when they do so, they often do not use the ventilation system during the night. Schreckenber (Schreckenber, 2012) highlights that noise insulation measures at home lack efficiency in order to reduce aversive noise effects such as annoyance.

These findings emphasize that the interventions that seem to be the most important often do not lead to the desired result in reducing annoyance. Schreckenber (2012) points out that while insulation has the potential to drastically reduce indoor noise levels, it cannot replace active noise control measures.

5.2.4 Providing Noise-Free Times

One example of a noise control measure which is currently studied in the vicinity of Heathrow Airport is the so-called noise respite (Porter, 2017). The development of satellite navigation technology allows an aircraft to fly more accurately on specified paths (performance-based navigation, PBN), resulting in a greater control over the noise distribution. The idea of noise respite is that flight paths are varied so that residents can enjoy noise-free times, while other residents experience more noise at the same time, and vice versa. By doing so, the aircraft noise can be shared across communities so that some communities experience respite. While there is currently neither a clear and consistent definition of respite nor of the duration of noise-free times to be perceived as respite, we note that relief can be defined as a break from or a reduction in aircraft noise. In contrast, respite can be defined as scheduled relief from aircraft noise for a period of time. The Respite Working Group currently claims that small changes in noise (i.e., 2–3 dB) are hardly noticed by residents. Residents would perceive an increase in noise rather than a decrease of similar magnitude (Porter, 2017).

At Frankfurt Airport, the concept of respite was also imposed in 2015, about 3.5 years after the opening of the fourth runway (October 2011) with temporary closure of two of the four runways in the shoulder hours (Schreckenber, Götz, & Flindell, 2016), which are the hours immediately before and after the night. In between these shoulder hours, from 11 p.m. to 5 a.m., there has already been a night curfew implemented at Frankfurt Airport since November 2011. Within these shoulder hours, this results in a decrease in exposure for some residential areas and an increase in other areas. In summary, however, this led to more residents being relieved from aircraft noise rather than being additionally burdened by it for the whole night from 10 p.m. to 6 a.m. Focus groups and a telephone survey revealed that these respite operations exert only marginal effects on the perception, and residents also hardly noticed any difference, perhaps because of the fact that aircraft sounds were still audible (though softer) in the shoulder hours. Moreover, only a minority of participants were informed about the operations being implemented. Nevertheless, participants were in favor of a continuation of the respite operations at Frankfurt Airport (Schreckenber et al., 2016).

5.2.5 Compensating Loss of Value

Another approach that refers to distributive fairness aspects is the financial compensation for the loss of value of real estate which had been observed, e.g., (Nelson, 2004). Buying up the properties by the airport is a measure that is already being practiced as, for instance, in certain districts at Frankfurt Airport (Fraport, 2005) after the opening of the new runway, and as is currently the case at Zurich Airport (Zurich-Airport, 2020). Additionally, Heathrow Airport announced compulsory purchases in the case of an additional runway being built (Heathrowexpansion, 2019). Further compensation programs grant owners a one-time monetary compensation for the impaired opportunity to use the outdoor living areas of a dwelling, as is already part of, for instance, the act for protection against aircraft noise (Federal Ministry for the Environment & Safety, 2007) and that of Dusseldorf Airport or Airport Berlin Brandenburg. Despite those efforts, systematic and empirical evidence of its effectiveness in, e.g., reducing annoyance has not been reported yet.

5.2.6 Increasing Individual Benefits

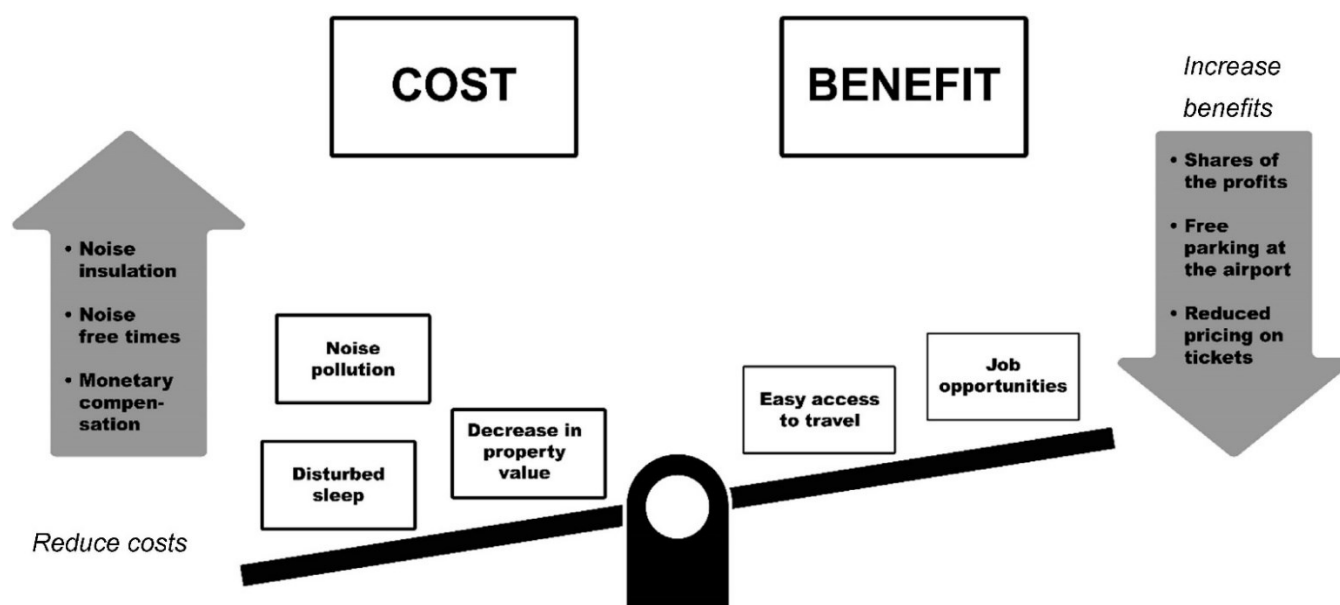
Whilst interventions focusing on the “reducing cost” part of the distributive fairness aspects have already been implemented, such as the ones mentioned above, interventions relating to increasing the individual benefits (of the airport) were, to the best of our knowledge, not yet introduced. To act in line with the social exchange theory (Adams, 1965), one would suggest

that interventions focusing on increasing the individual benefit also contribute to the perception of fair distribution. As depicted in Figure 3, the overall goal is to balance the cost–benefit ratio of residents. Besides the already mentioned interventions to reduce the individual costs, examples of interventions to increase the personal benefit, which were derived from a focus group study performed around Cologne-Bonn airport (Hauptvogel, 2021), would be:

- Providing shares of the profits from the airport;
- Free parking at airports;
- Reduced pricing on flight tickets.

These exemplary interventions to increase individual benefits while being exposed to aircraft noise have been neither implemented nor evaluated, so no assertion can be made about the effectiveness.

Figure 3. Illustration of Balancing the Cost-Benefit Ratio



Note. Own figure to illustrate the individual cost and benefits of an airport in the proximity and possible ways to balance this (Hauptvogel, Bartels, Schreckenber, & Rothmund, 2021a).

Social justice research has revealed that people not only focus on the outcome when they judge the fairness of a distribution; whether people perceive themselves being treated fairly or unfairly is also determined by features of the process, i.e., how the distribution was decided and communicated.

5.3 Procedural Fairness

Since the 1970s, a substantial amount of research indicates that the perceived fairness of a distribution is strongly affected by the procedures that are used to decide the distribution (Lind & Tyler, 1988; Thibaut & Walker, 1975; Tyler & Lind, 1992). The so-called fair process effect is one of the most prominent findings in this context (Lind & Tyler, 1988; van den Bos et al., 1997a). It indicates that when participants have a voice in an allocation decision, they perceive the outcome as fairer and evaluate it more positively, irrespective of the final distribution. Research on the fair process effect suggests that a fair process might have more influence on the overall fairness evaluation than the outcome itself (Lind & Tyler, 1988). This section summarizes the findings from research on procedural fairness and describes how these findings can be used in the area of aircraft noise allocation.

5.3.1 *What Is Procedural Fairness?*

As described, it was becoming increasingly clear that people are not only concerned with the outcomes of a decision, but, more importantly, with the procedures that lead to the decision. Thibaut and Walker (1975) first examined procedural fairness in situations when a decision was made by a third party or legal authority that had consequences for an individual. The authors argued that a procedure is perceived as fairer when the individual has some amount of control in the decision-making process. They distinguished between process control and decision control. Process control means that an individual has the chance to express his or her perspectives and to bring arguments before the decision is made. Decision control, in contrast, refers to the actual amount of influence the individual has on the decision-making process.

The importance of procedural aspects can be explained via the theoretical framework of Stallen (1999).

Procedural fairness can be seen in this context as a coping possibility because it fulfils different psychological needs. Procedural fairness is important for people because it conveys information about one's status in the group. Being granted some amount of control in the process of a decision implies that one is a valued member of a group and thus enhances the feeling of belonging and self-esteem (Lind & Tyler, 1988; Tyler & Lind, 1992). Information about procedural fairness is also known to heuristically reduce uncertainty in social relationships (van den Bos & Lind, 2002). Thus, perceived procedural fairness is used as an indicator of trustworthiness when people want to reduce the uncertainty of not knowing if an individual or a party can be trusted (see Bobocel & Gosse, 2015; Lind et al., 1993; van den Bos, Vermunt, & Wilke, 1997b). Essentially, a fair procedure operates psychologically in a similar

fashion to stereotypes; thus, it helps humans to reduce uncertainty in a fast and frugal manner and is therefore assumed to reduce stress (van den Bos & Lind, 2002; van den Bos et al., 1997a). In line with these notions, research in the occupational and legal context revealed that fair procedures have an impact on pay evaluations (Tyler, 2000; van den Bos et al., 1997a); job satisfaction; trust in the management, e.g., (Alexander & Ruderman, 1987) organizational commitment, and job performance (Colquitt et al., 2001); and on attitude towards judges and the court (Tyler, 1984). Nonetheless, how can procedural fairness be achieved?

5.3.2 Characteristics of Procedural Fairness

Leventhal (1980) developed six criteria for procedural fairness (listed below) which were mainly examined in the context of organizational psychology. A meta-analytic review indicates that the combination of these criteria is a better predictor of perceived procedural fairness than process control alone (Colquitt et al., 2001). The application of these theoretical considerations from Leventhal (1980) in the context of the aircraft noise problems leads to the following recommendations on how procedures that determine noise-related decisions should be designed:

1. Representativeness: During all phases of decision-making procedures (e.g., the opening of a new runway), the concerns and opinions of all affected citizen should be represented. This could, for example, be carried out via an open hearing or by having representatives for each party. This picks up the idea of giving residents a “voice”.
2. Consistency rule: Procedures are consistent across residents. In other words, the criteria for when and how an airport pays for noise insulation or compensation measures are transparent and applied coherently for every resident; nobody is given an advantage or disadvantage.
3. Bias suppression rule: Decisions by the airport or airport stakeholders should not be taken solely for self-interest and economic reasons, although the operation of an airport is initially exclusively economic in nature. For example, noise thresholds and thus decisions to ban night flights or certain loud aircrafts should be based on scientific knowledge of health effects. To prevent decisions based on self-interest, neutral bodies such as ombudsmen should be involved.
4. Accuracy rule: The allocative process is based on sufficient, correct, and appropriate information. In this case, e.g., noise insulation schemes should be based on the most recent scientific data about the impact of noise on health.

5. Correctability rule: Opportunities exist to alter or reverse an inaccurate decision at various stages of a process. Accordingly, all parties involved in this process have the chance to appeal or challenge a decision. This should imply that, e.g., night flight permissions should be revoked if new insights on the effect of nocturnal noise and noise-induced sleep disturbance on health outcomes are obtained. If decisions are made that affect the citizens concerned, they should be reconsidered and adapted accordingly in light of newer knowledge.
6. Ethicality rule: Processes that lead to a certain noise distribution should generally be in line with fundamental ethical and moral standards. In concrete terms, this means that decisions on noise distribution should be approved by, for example, an ethics committee. An ethics committee could surveil whether sub-populations are treated equally or whether the noise distribution is associated, for instance, with the socio-economic status of the residents of noise-exposed areas. Moreover, it can decide, for example, to appeal against the night flights at an airport if the recent research on the effects of noise at night reveals that lasting damage can be caused to the affected inhabitants.

In summary, procedural fairness research provides an understanding of the boundary conditions in which decisions about distribution and exposure to aircraft noise are more readily accepted by the public and met with less resistance. The empirical evidence on the role of procedural fairness in the evaluation of noise distribution should also be considered.

5.3.3 The Benefit of Fair Procedures in the Distribution of Aircraft Noise Exposure

The contribution of perceived process and decision control to annoyance judgments was studied experimentally in the laboratory. Maris et al. (2007b) ran two laboratory experiments that focused on voice and process control as one aspect of procedural fairness. In the first experiment, the participants who could voice their preference for a certain sound (i.e., bird song, radio sound or aircraft sound) and who believed that this preference was considered (fair procedure) were less annoyed by aircraft noise than participants who could not voice their preference (neutral procedure) and who were also exposed to an aircraft sound. In the second experiment, it was shown that participants who voiced their preference and whose preference was ignored (unfair procedure) were significantly more annoyed than participants who could not voice a preference (neutral procedure).

Moreover, a survey with airport residents Jue et al. (1984) showed that residents who think that “the opinion of all the citizens directly affected by the airport will make a difference

in the decisions about the airport and the area surrounding it” (p. 341) are less annoyed than residents who disagreed with this statement.

In fictive airport expansion scenarios that differed, among other things, in the amount of participation opportunities for residents (few or manifold), it was shown that when offered manifold participation opportunities, subjects around two European airports exhibited more social acceptance of the (fictional) expansion plans than when only given few participation opportunities (Liebe et al., 2020).

In a field study within the NORAH project, which was a multidisciplinary research project examining the effects of noise on annoyance, cognition and health, Schreckenberget al. (2017b) performed a sensitivity analysis and concluded that considerable differences between annoyance ratings depended on the procedural fairness perception of residents.

Thus, when decisions are being taken regarding airport expansion plans, new take-off and landing procedures, a prolongation of operations at night or the establishment of a runway alternation system, it is important to create a framework that makes use of fairness–psychological findings, enhancing the probability of these being perceived as a just course of action. As it could be shown, a fair procedure offers the possibility of dealing with the necessarily unfair distribution of aircraft noise.

However, it has to be stated clearly that this does not mean that the distribution of noise over the population has no influence on the perception of fairness, but the framework conditions leading to this certain distribution could be created in such a way that it essentially influences subjective fairness assessments. Cohen (1985) voiced concerns about the potential abuse of procedural fairness as it enhances the subjective feeling of fairness, even though the objective criteria could be patently unfair.

5.3.4 From Theory to Practice—Incorporating Procedural Fairness Aspects in Aircraft Noise Management

Aircraft noise interventions have mostly focused on the mitigation of noise at the source as well as operational restrictions and land-use planning in accordance with the balanced approach to aircraft noise management suggested by the International Civil Aviation Organization (ICAO). However, the importance of including residents’ perspectives in a balanced approach to aircraft noise management was recently underlined by the ICAO (2017). Measures such as providing an opportunity for residents to give feedback and express their views which meet the crucial criteria of procedural fairness have been recommended. However, the degree to which airports carry out such participatory communication is limited, and evaluations of the benefit of such measures almost never happen (Heyes et al., 2020).

In contrast, mistrust between the opposing parties in airport-related decision making, the impossibility for the voice of affected residents to be heard, and the lack of transparency of the airport operators, thereby fostering protests and mobilization against an airport expansion, was demonstrated (Suau-Sanchez et al., 2011). In this case study from Barcelona Airport, residents were given false promises about the noise generated by the construction of a new runway and the use of certain configurations, which made it impossible to predict the time and level of noise exposure. In this example, citizens affected by the noise proposed technical solutions that reduced the noise in those areas while simultaneously allowing the airport to operate properly. The proposal made by the citizens was very effective in reducing noise levels by 15–20 dB L_{eq} and brought a period of peace between the airport and affected residents.

Reviewing different case studies in regard to communication and engagement efforts conducted by European airports, Heyes et al. (2020) identified Heathrow, Vienna and Frankfurt as those where the airport does not take the dominant role as the “expert”. The Vienna Dialogue Forum offers the only real opportunity in the vicinity of an EU airport for a real two-way exchange, providing all participants with a voice. The Vienna Dialogue Forum is the most extensive mediation process in Europe, which was implemented with the planning of the third runway at Vienna Airport. In this mediation process, around 50 interested parties, such as action groups and neighborhood communities, are working together to find solutions that would be acceptable for all involved parties (Viennaairport, 2020).

All parties are represented in the process; this the Vienna Dialogue Forum cares for consistent procedures, bias is suppressed since the airport is not the one in charge, and the results should be based on accurate and ethical considerations. Although this seems to be a good example of how procedural fairness can be implemented in the context of aircraft noise politics, its impact has not yet been evaluated.

In the context of respite, Porter (2017) also pointed out that for respite to be really helpful for communities, it is important to engage all communities during all phases of respite design and implementation. Recently, Porter (2017) explained that more effective and successful implementations of respite have proactively engaged and consulted with the local communities.

5.4 Informational and Interpersonal Fairness

Research from justice and organizational psychology has shown that fair procedures including opportunities to have one’s voice heard do not suffice for the feeling of being fairly treated. Instead, the quality of interaction between the involved parties, i.e., the way these decisions are

communicated to the affected people, also matters (Bies, 2001). In this final part of the paper, we present fairness aspects regarding information provision and interaction between the airport and residents and discuss why these aspects are important.

5.4.1 What Is Informational and Interpersonal Fairness?

Bies and Moag (1986) introduced the construct of interactional justice which focuses on the quality of the interaction between decision-makers and individuals that are affected by these decisions (Bobocel & Gosse, 2015). Subsequently, this concept has been further differentiated into interpersonal fairness and informational fairness. Interpersonal fairness focuses on the degree to which people are treated with politeness, dignity, and respect by the decision-making party (Greenberg, 1993). Informational fairness describes the quality of the explanations given to the affected people that justify the reason for the application of a certain decision-making procedure or the distribution of the outcome in a certain way (Greenberg, 1993).

In other words, communication management of the airport should not only provide engagement opportunities for residents but also communicate in a way that is perceived as fair. Sommerfeld (2013) provided empirical evidence for this assumption. Based on qualitative interviews, she concluded that residents ask for better, i.e., more comprehensive and transparent, communication and information in terms of creating a better relationship with the airport. In a similar vein, other studies revealed that residents most often desired honest and comprehensive information when asked what the airport could do to achieve and maintain good neighborliness, (Haugg, Kastner, & Vogt, 2003; Maziul & Vogt, 2002). Moreover, Maziul and Vogt (2002) argued that the introduction of a free-toll telephone service that enables residents to receive aviation-related information might be able to reduce community annoyance.

5.4.2. How to Create a Fair Interaction between the Airport and Its Residents?

Bies and Moag (1986) focused on fairness in terms of interpersonal treatment on the one hand and communication and information on the other hand and postulated four criteria that people use to evaluate interpersonal fairness, which can be applied easily to the aircraft noise context:

Criteria of informational fairness:

1. Truthfulness: Communication from the airport should be made in an honest and candid way. This means that residents must be informed about the scope, duration and level of noise during the decision-making processes (Nanz & Fritsche, 2012). This form of truthfulness stands in conflict with a strategy of downplaying potential burdens of noise exposure to avoid protests and complaints by the affected residents. From the residents'

perspective, this strategy might be understood as a kind of deception, especially when the claims ultimately prove false.

2. **Justification:** Decisions regarding noise exposure are perceived as fairer when an adequate justification or reasoning is provided (Bies & Shapiro, 1987), for example, when objectives and intentions are honestly and openly explained. The timing of justification also matters. When decisions are made about aircraft noise, the final outcome is seen as fairer if information about the process is given in advance than if it is given after the outcome has been determined. This implies that information should always be provided as early as possible (van den Bos et al., 1997b).

Criteria of interpersonal fairness:

3. **Respect:** The interaction should be respectful and polite, i.e., the airport should treat the affected citizens with respect. All subjective feelings must be taken seriously, and residents should be encouraged to actively participate in the decision-making process. The airport should emphasize the relevance of each resident and listen to their feelings and perceptions.
4. **Propriety:** Prejudicial and improper comments are avoided, even when dealing with enraged citizens. Even when interacting with very angry residents, responsible contact persons must be friendly, polite, and courteous at all times. It is important to understand that residents may be emotional and heated and, therefore, sometimes behave in an unfriendly manner.

5.4.3 Setting the Right Tone—Interactional Justice in Practice

In the context of respite, the working group of Porter (2017) found out that good communication and transparent engagement is key for the successful implementation of respite programs.

Additionally, an example of how informational fairness can be beneficial is the study conducted by Schreckenberget al. (2013). In two geographically separated study areas along a railway line in south Germany, the impact of railway grinding on residents' responses to railway noise was investigated. Rail grinding was applied on this railway line, a measure to reduce the roughness of rail surfaces with the consequence of lower noise levels emitted by contact of the wheel on the railroads. Despite having almost zero effect on the overall noise level reduction, in the study area in which residents were informed about the grinding and its noise-reducing effect prior to the intervention, participants reported lower levels of annoyance and disturbances afterwards than before, whereas in the uninformed area, no change in noise disturbance and annoyance responses was observed. The message of this study is not to issue press releases of

fictitious interventions, but rather to highlight that providing information about interventions can enhance its effectiveness.

Furthermore, Hooper and Flindell (2013) draw conclusions on the results of recent and mainly qualitative research and claim that residents often believe that authorities have no real interest in communicating at eye level with the public as current information is “too complicated, over-technical and does not even focus on information which the public actually want or need to know” (Hooper & Flindell, 2013, p. 1). The authors point out that providing understandable information to residents could make them more tolerant and accepting because it increases understanding and allows residents to identify and focus on real issues of importance, but also the limitations of what can be done. Gasco, Asensio, and de Arcas (2017) have also found this to be the case, as currently, the communication of information on noise is too technical to be understood by lay people, certain standards are lacking to compare noise between airports, the measurement points are sometimes incomplete and do not reflect the actual noise nuisance and, finally, little feedback from affected citizens is seen and incorporated into the information preparation (Gasco et al., 2017).

A good example of interactional fairness is represented by the Vienna Dialogue Forum since this mediation process is based on mutual respect and propriety (dialogforum.at, 2005). Approximately 50 affected parties (both neighborhood associations and interest groups) are represented at eye level in this mediation process. Necessary information is provided in a transparent and truthful manner in order to arrive at decisions that are appropriate and acceptable to all concerned.

As Flindell pointed out, “(qualitative research could reveal that) many residents will tolerate being annoyed from time to time if they also understand what has been done to reduce the problem and why the remaining annoyance is unavoidable. (But the) airports (need) to fully engage with their surrounding communities to explain and justify (in a respectful and polite manner) where noise is unavoidable and to make their economic and social contributions to general welfare much more explicit” (Ian Flindell & Associates & MVA Consultancy, 2013, p. 23).

5.4.4 Recommendations for Practical Implementation

In this review, we outlined the dilemma of fairness in the distribution of aircraft noise from the perspective of fairness research. As the accessibility of airports is generally not only necessary but even desirable, noise has to be distributed over a certain airport region, which will ultimately put more strain on some residents compared to others. By taking different perspectives on the

psychology of fairness into consideration, we argue that such an overall unfair event, such as the distribution of noise, can still be perceived as more or less unfair. In Table 3, we summarize the findings of this review and suggest concrete applications of fairness principles in the context of planning strategies and communication management of airports and describe to what extent they seem feasible to implement. It is important to note that these are the opinions of the authors, as empirical evidence is scarce.

Table 3. Summary and Practical Implications of Fairness Research

Fairness Category	Fairness Aspect	Application	Feasibility
Distributive fairness	Creating fair noise distribution	Distribute noise (a) to protect residents with special needs (children, sick or elderly), (b) equally over as many residents as possible, (c) in such a way that the highest number of residents will be protected.	Little empirical evidence on which principle of distributive justice is perceived as fairest by residents.
	Improving the individual cost–benefit ratio by:		
	(a) Reducing noise and noise-related burden	Noise insulation, providing noise-free times and spaces, compensation (buying up properties, providing monetary compensation).	Noise reduction interventions are often regulated by national law. However, there is a lack of empirical evidence on which of the implemented interventions is (most) effective.
	(b) Increasing individual benefit	Providing shares of the profits from the airport, free parking at airports or reduced pricing on tickets.	New type of intervention derived from the literature presented here. However, there are no empirical studies on this.
Procedural fairness	Bias suppression	Decisions taken by the airport are not exclusively led by self-interest and economic reasons.	Involving independent and neutral bodies (e.g., ombudsmen) could be an important component of a fair decision-making procedure.
	Representativeness	Provide opportunities and ensure opinions of affected residents are represented during all phases of the decision making.	The Vienna Dialogue Forum can be a model for the implementation.
	Consistency	Procedures are kept consistent between residents (e.g., criteria for noise insulation, noise protection zones).	Legislation is not the same throughout the country, so consistent treatment of all citizens is difficult to implement.
	Accuracy	Decisions regarding noise distribution should be based on sufficient, correct, and appropriate information.	By including scientific advisors, this step should be easily applicable.
	Correctability	Affected parties have the opportunity to challenge a decision (e.g., night flight permissions)	Affected persons should be able to challenge any decisions at any time. However, this would require a

			change in legislation and is therefore rather difficult to achieve.
Informational fairness	Truthfulness	Communicating to residents in an honest, transparent, and candid way. Informing about the impact of change (e.g., opening a new runway) has to be truthful, exhaustive, and understandable, even when communicating negative news.	This point is both simple to implement and effective.
	Justification	Justifying, e.g., the decision to build a new runway comprehensively, in a timely manner and in a language that laymen understand so that relevant information is not “hidden” behind technical jargon and abstract noise exposure metrics.	Creating a resident-oriented communication can be achieved without any further costs but requires understandable metrics.
Interpersonal fairness	Propriety	Avoid uncivil behavior and prejudicial and improper comments. Every interaction, even with angry residents, has to be impartial and polite.	Communicators can be trained to deal with residents, and this should be easily implemented.
	Respect	Every interaction should be respectful and polite. Respect residents’ feelings and perceptions and encourage active engagement in the decision-making process.	Same as for propriety

Note. Own table to summarize the results of the review of fairness facets and their specific application and feasibility in the context of aircraft noise management.

5.5 Conclusions and Outlook

This paper had two main objectives. First, we aimed to analyze the fairness dilemma of aircraft noise distribution from the perspective of social justice research. Second, we aimed to identify ways of dealing with this unfair distribution of noise and provide recommendations on how to implement fairness considerations in concrete interventions to reduce annoyance from aircraft noise.

The fairness dilemma results from the practical problem that aircraft noise is generally shouldered by a group of residents, while the benefits of the airport are shared by all residents. We outlined and discussed different forms of fairness, namely, distributional fairness, procedural fairness and informational or interactional fairness, as distinguished in the scientific literature on the psychology of justice. All of these different perspectives provide unique and valuable insights on how to reduce perceived unfairness in the process of noise distribution. However, the empirical evidence on fairness perception by residents in the field of aircraft noise reduction is scarce. Precisely because the empirical evidence base is so small, future research is of great importance. Unfortunately, there are currently no established psychometric questionnaires available to measure fairness perception in the context of noise research in a valid and reliable way. Thus, there is a need for the development of psychometric instruments. In order to gain a deeper understanding of the nature of fairness evaluations, qualitative studies (e.g., focus groups) should also be conducted with airport residents.

We outlined existing interventions in the field of aircraft noise distribution that have considered specific aspects of fairness research. However, the theoretical principles have not been applied systematically in the past. Therefore, we derived concrete recommendations from social justice research on how perceived fairness in the distribution of aircraft noise can be increased. These recommendations are summarized in Table 3. It must be noted that these practical recommendations are exemplary and might not cover the full range of potential applications. Importantly, there is a lack of empirical evidence on how capable these interventions are at reducing the impact of the fairness dilemma on the perceived annoyance from noise. Future research is needed to systematically evaluate the effectiveness of such fairness interventions. Many of these recommendations require additional effort on the part of agents in airport management and communication. However, research in other areas (e.g., organizational justice) provides us with confidence that these efforts can improve the effectiveness of other measures to reduce annoyance from aircraft noise and increase the acceptance of the airport and local aviation.

6. “The Airport does what it wants to do anyway.” What Constitutes a Fair Relationship with the Airport from the Perspective of Airport Residents? – A Qualitative Study Approach³

Abstract: Long-term exposure to aircraft noise has been linked to various negative health impacts, with annoyance playing a key role in mediating stress-related health effects. Previous research indicates that fairness can be seen as a fundamental aspect potentially reducing annoyance reactions. This study examines different aspects of fairness in airport management, focusing on the perspective of affected residents. The research involved conducting focus group discussions and in-depth interviews at three different European airports in Germany and France. These sessions were transcribed and analyzed using qualitative content analysis. Participants were surveyed based on their exposure to lower (≤ 55 dB L_{den}) and higher (> 55 dB L_{den}) levels of aircraft noise. The findings indicate that distributive, procedural, informational, and interpersonal fairness are viewed as important elements for fostering a fair and neighborly relationship with the airport. Residents particularly emphasized the importance of receiving adequate compensation for the costs they incur due to their proximity to the airport, such as sleep disturbance caused by noise. Additionally, residents expressed the need for genuine inclusion in the decision-making processes at the airport, as well as access to honest and transparent information. Additional focus group discussions were conducted to gather input from affected residents, aiming to establish a fair and neighborly relationship. Based on these insights, recommendations are formulated for airport managers with the objective of establishing a fair and neighborly relationship with the affected residents.

6.1 Introduction

Research on the effects of aircraft noise have repeatedly shown that long-term noise exposure is associated with a variety of adverse health effects, such as annoyance due to aircraft noise

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(Bartels et al., 2018; Guski et al., 2017), sleep disturbance (Basner & McGuire, 2018; Smith et al., 2022) and cardiovascular and coronary heart disease (Babisch, 2014; Roca-Barceló et al., 2021; van Kempen et al., 2018) such as myocardial infarction (Babisch et al., 2005), and hypertension (Dratva et al., 2012). Even in children and newborns, noise can have adverse effects on health (Erickson & Newman, 2017), cognition (Klatte et al., 2013) and learning ability (Klatte et al., 2017).

Annoyance is considered as one of the most important effects of noise and can occur even at lower noise levels, widely experienced in areas around airports (Guski et al., 2017). Noise annoyance is seen as a kind of stress response to noise, that manifests in cognitive, emotional and behavioral aspects (Guski et al., 2017). Current research suggests that high levels of long-term noise annoyance can mediate adverse health-effects and is associated with a higher risk for hypertension (Baudin et al., 2020), a decrease in mental well-being (Schreckenberg et al., 2017a), higher levels of psychological distress (Baudin et al., 2018), and medication use to treat anxiety disorders (Baudin et al., 2021). When evaluating sound as noise, stress triggers a series of responses in the human body due to the activation of the sympathetic nervous system and the release of stress hormones like epinephrine, norepinephrine and cortisol (Babisch, 2002). Reducing annoyance is therefore assumed as an essential factor when mitigating the negative, health-related consequences of long-term noise exposure (Benz et al., 2022; Guski et al., 2017; Stallen, 1999).

Research has repeatedly shown that annoyance reactions are only partly determined by the sound level itself (Guski, 1999; Guski et al., 2017). Non-acoustic factors can explain a major part of the seen variations in annoyance reactions of residents exposed to aircraft noise (Bartels, 2014; Flindell & Stallen, 1999; Guski et al., 2017; Schreckenberg et al., 2017b). Non-acoustic factors include aspects such as trust in authorities, predictability of noise events, the feeling of having control over the noise source, and having access to understandable information (Bartels et al., 2022; Guski et al., 2017; Stallen, 1999).

As shown in the review by Hauptvogel et al. (2021a), perceived fairness in airport management may influence many of these non-acoustic factors and might be able to mitigate noise annoyance reactions. From a psychological point of view, fairness is crucial for humans as it enhances the feeling of control (Lind, Kanfer, & Earley, 1990), provides a feeling of being a valued member of a group (Lind & Tyler, 1988), reduces psychological uncertainty (van den Bos & Lind, 2002), and is able to reduce stress levels even on a physiological level (Vermunt & Steensma, 2003).

Incorporating fairness into the context of aircraft noise management has therefore the potential to impact numerous non-acoustic factors, including predictability through informational fairness and trust through long-term truthfulness and justification as well as opportunities to enable participation in decision making (Hauptvogel et al., 2021a). As a result, fairness can potentially have a multi-dimensional impact, reducing annoyance and ultimately increasing trust in the long-term, and thus, enhancing the acceptance of the airport and the local air traffic.

In the field of psychological fairness research, there are four distinct facets of fairness that are commonly recognized: distributive, procedural, informational, and interpersonal fairness (for an overview, see Colquitt et al., 2001). Research on distributive fairness originates from the organizational and judicial context and suggests that fairness is assessed based on a perceived cost-benefit ratio, as proposed by Adams (1965). Seen in the context of organizational psychology, individuals evaluate the costs they bear, such as time and physical effort, and compare them to the benefits they receive in the form of wages or salaries. In the context of aircraft noise research, equity may be perceived when there is a balance between the costs associated with aircraft noise exposure (e.g., sleep disturbance or property devaluation) and the benefits perceived (e.g., travel or job opportunities). Leventhal's considerations (1980) provide additional principles for distributing aircraft noise. The equality rule suggests distributing aircraft noise equally among all residents, regardless of other environmental stressors. Conversely, the needs rule advocates for protecting vulnerable groups, such as children, the sick, or the elderly, from additional noise exposure, distributing the noise over the rest of the population. Up to now, there is no answer to what distributions of noise is seen as more fair than the other (Hauptvogel et al., 2021a).

Procedural fairness is rooted in the notion that individuals perceive fairness when they have been given a voice or control during the decision-making process (Lind & Tyler, 1988; Thibaut & Walker, 1975; Tyler & Lind, 1992). Research on procedural fairness highlights that the process leading to a decision is often more important as the actual outcome of these decisions (Lind & Tyler, 1988). In addition to process and decision control as important components of a fair process (Folger, 1977; Thibaut & Walker, 1975), Leventhal (1980) introduced additional principles for assessing the fairness of a procedure. These criteria include representativeness, where the concerns and opinions of all affected parties should be considered at every stage of the decision-making process. The consistency rule emphasizes the consistent application of procedures across all residents and times, while the bias suppression rule specifies that decisions should not be influenced by self-interest (economic reasons) but rather

adopt a non-biased perspective. The accuracy rule suggests that decisions should be based on correct and appropriate information, and the correctability rule proposes opportunities for revising incorrect or inaccurate decisions. Finally, the ethicality rule states that processes should adhere to fundamental ethical and moral standards.

In addition to the distributional and procedural fairness, research highlights that the interaction between the parties is also of importance in the final perception of fairness (Greenberg, 1993). Research has shown that unfairness can be perceived even if a fair decision has been made from the point of view of distributive and procedural fairness, due to the fact that this decision has not been adequately communicated with those affected by it. Research indicates that it is not enough to give individuals the opportunity to voice their concerns during the decision-making process, but eventually also communicate the decisions in a fair manner (Bies, 1986; Skarlicki & Folger, 1997). Informational fairness highlights the importance of communicating honestly and justifying decisions in details. On the other hand, interpersonal fairness suggests that airport authorities should interact with residents on a basis of respect and propriety.

To gain a comprehensive understanding of fairness in the context of aircraft noise, it is essential to actively involve residents impacted by this issue. By examining their unique experiences and interpretations through the lens of fairness research, we can identify the necessary conditions for residents to perceive airport management as equitable and fair. Incorporating the perspectives and experiences of affected residents is crucial for a comprehensive understanding of fairness issues related to aircraft noise mitigation.

Up to now, qualitative research on fairness in the aircraft noise debate has been limited. However, studies such as Sommerfeld (2013) and Hooper and Flindell (2013) have shed light on residents' desires for improved communication and transparent information provision, highlighting the importance of informational fairness. Residents expressed dissatisfaction with the current state of information and felt that airports lacked genuine interest in engaging with them on an equal basis. Flindell, Le Masurier, and Le Masurier (2021) emphasized the significance of qualitative research, which revealed that residents generally exhibited tolerance towards airports and recognized that noise disturbances are sometimes unavoidable. However, to foster such tolerance, airports must actively engage with residents and establish respectful communication and information policies. This includes explaining decisions where noise mitigation is not feasible and highlighting the airport's economic and social contributions to the surrounding region.

In order to close the existing research gap and to systematically and comprehensively grasp the aspect of fairness with all its facets, this paper aims to achieve three objectives:

1. Determine how statements from residents impacted by aircraft noise can be categorized according to the four facets of fairness: distributive, procedural, informational, and interpersonal fairness.
2. Identify which facets or subfacets are deemed particularly significant by residents, warranting special consideration.
3. Explore the perspectives of residents regarding interventions that aim to cultivate a neighborly relationship between residents and the airport.

By examining these objectives, this research seeks to gain a deeper understanding of the aspects of fairness that residents value the most in relation to aircraft noise distribution.

6.2 Methods

The results presented here were obtained within the framework of the EU project ANIMA (Aviation Noise Impact Management through Novel Approaches). This project received funding from the EU Horizon 2020 research and innovation programme under grant agreement No. 769627. An overview of the aims of Work Package 3 and Subtask 3.2.1 in which the focus group discussions and in-depth interviews were conducted as well as further results can be found in the published deliverable (Hauptvogel et al., 2021b).

6.2.1 Design

The present study utilized a multicentered, multimethod qualitative study design, with data collection between December 2019 and April 2020.

To address the Research Questions, this study comprised two stages:

In the first stage, focus group discussions and in-depth interviews were conducted at three European airports (Cologne-Bonn Airport, Dusseldorf Airport, and Paris-Charles-de-Gaulle Airport). Specifically, four focus group discussions were conducted at Cologne-Bonn Airport, with two groups representing regions less affected by aircraft noise (≤ 55 dB L_{den}) and two groups representing regions more affected by aircraft noise (> 55 dB L_{den}). Similarly, four focus group discussions were carried out at Paris-Charles-de-Gaulle Airport, with also two

groups from highly affected regions and two groups from less affected regions. Additionally, a total of 22 in-depth interviews were conducted around Dusseldorf Airport.

The obtained data was used to categorize statements from the participants to the four fairness facets, namely distributive, procedural, informational and interpersonal fairness (Research Question 1) and further to identify which facets and subfacets are particularly important in the view of affected residents (Research Question 2).

To validate the results from this first stage and to answer Research Question 3, additional focus group discussions were conducted at Paris-Charles-de-Gaulle Airport. Here, the participants were presented with the results from the first stage and were asked specifically to think about specific interventions the airport could implement to foster and establish a positive relationship between the airport and the residents living near it. This stage was therefore not connected to the first stage of data collection and can be seen as an additional step to validate the results to gain a deeper understanding of what residents see as possible and effective interventions.

The decision to employ a qualitative research method in this study was driven by the limited attention given to fairness within the domain of aircraft noise research, along with the scarcity of systematic work addressing this topic. Qualitative research offers a significant advantage in its ability to uncover underlying motives, attitudes, and perceptions that are not easily captured through quantitative approaches (Brüsemeister & Brüsemeister, 2008). The objective of this study was not to conduct a representative survey, but rather to gain an in-depth understanding of the experiences and motivations of individuals affected by aircraft noise. By utilizing focus group discussions as a qualitative research method, we further benefitted from the emergence of discussion topics through group dynamics, which may not have been elicited through conventional data collection methods. This approach therefore helps to better understand residents experiencing aircraft noise in their daily lives and gives important insights into their thoughts, motives and experiences.

6.2.2 Study sample

In the study areas surrounding Cologne-Bonn Airport, flyers were distributed and posters were displayed in local retail businesses. Special recruitment agencies were employed to handle the recruitment and participant selection around the airports of Dusseldorf and Paris-Charles-de-Gaulle.

The study pre-screened potential participants through a survey that covered demographic information such as gender, age, marital status, and education, as well as

questions related to their residential circumstances such as length of residency, tenure status, and overall satisfaction with their living environment. Additionally, participants were asked about their connection to the airport, such as whether they were employed there or are an active member of a citizen organization. A complete list of the survey questions and sample composition can be found in Deliverable D3.9 of the ANIMA Project (Hauptvogel et al., 2021b). The aim here was to get a mixed group of people in the focus group discussions to stimulate discussion through the different perspectives.

All participants signed an agreement before data collection that the data would be collected and to consent to an audio recording. The study was also approved by the Ethics Committee North Rhine with the consecutive number 2019235.

6.2.3 Procedure

Noise sampling

The noise exposure of each region considered in the study was determined around Cologne-Bonn and Dusseldorf from the publicly available environmental noise maps for North Rhine-Westphalia published by the Ministry for the Environment, Nature Protection and Transport of the State of North Rhine-Westphalia (NRW) (Ministerium für Umwelt, 2017). Aircraft noise exposure was estimated for focus groups around Charles-de-Gaulle Airport through the publicly available Noise Exposure Plan (PEB) maps (Francaise, 2022). Care was taken to ensure that aircraft noise was the dominant noise source in the respective region.

Interview procedure

At the beginning of each focus group discussion, participants were welcomed and introduced to the overall procedure. To avoid influencing participants' responses, the purpose of the research was not disclosed in advance; participants received the information that the study topic was quality of life in airport regions. The discussion guide was structured with specific questions and prompts that amongst others covered the following topics:

- A description of what an ideal and fair neighborly relationship with the airport would look like.
- Participants' current perceptions of communication and information dissemination related to the airport.

- Expectations for information dissemination (e.g., what type of information is needed, who should provide it, and how the information should be provided).

The focus group discussions lasted between 1 to 2 hours, and the in-depth interviews lasted on average 26 minutes. Participants were compensated with € 30 (Dusseldorf Airport and Paris Charles-de-Gaulle Airport) and € 50 (Cologne-Bonn Airport) for their participation in the study. To facilitate analysis, audio recordings of both the focus group discussions and in-depth interviews were made with the consent of the participants. Participants around Cologne-Bonn Airport received higher compensation (€50) because a pre-test indicated that offering €30 did not yield as high a response rate.

Additional focus group discussions

As described in Section 6.2.1, additional focus groups were conducted to validate the results and address Research Question 3, focusing on creating interventions for a fair and neighborly relationship with the airport.

The discussions began with introductory questions to understand participants' attitudes towards the airport, such as their ideal relationship with it. The findings from the initial focus group discussions were presented to the participants to confirm the previous results and ensure their reliability. This was done using the Chinese portrait method (e.g. Maison, 2018), which prompted participants to associate fairness with places and objects. The goal was to emphasize fairness and prepare participants for further exploration.

The final part aimed to connect the perception of fairness to the current airport situation. Participants were asked to envision what interventions would look like if they were to put the ideas into practice. This step required participants to apply the abstract concept of fairness to a real-world context—their relationship with the airport. This comprehensive approach activated cognition and aimed to achieve practical results using the implementation intentions strategy by Gollwitzer (1999). The objective was to understand how justice elements can be effectively applied in practice.

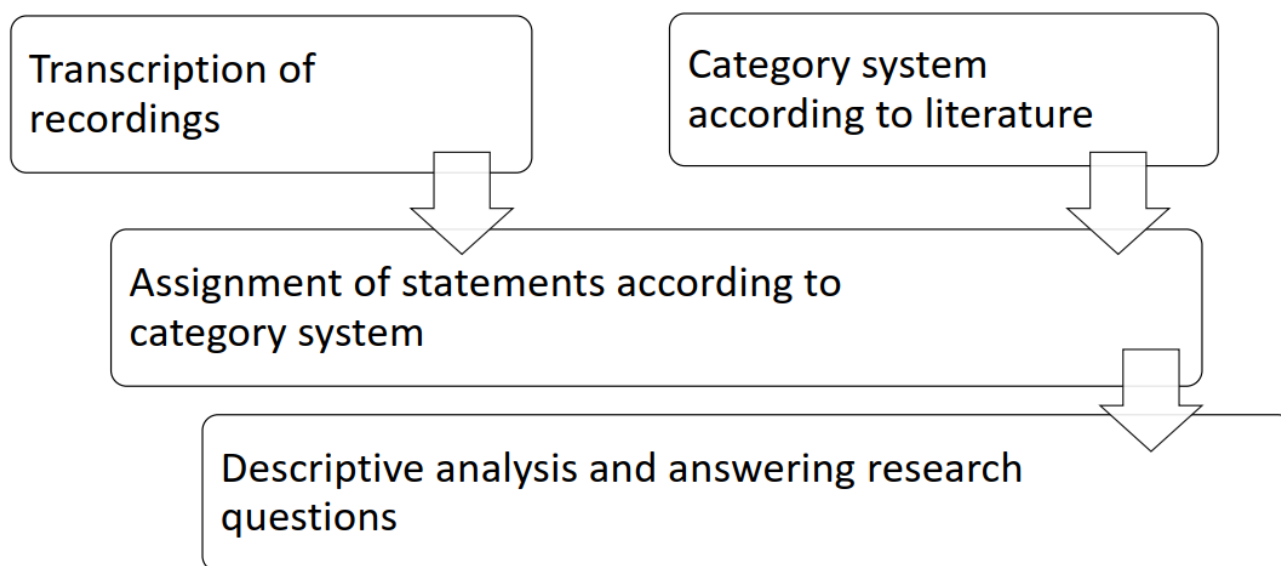
6.2.4 Analysis

Figure 4 illustrates the various stages of data analysis employed for analyzing the focus group discussions and in-depth interviews in the main study.

The audio recordings of the focus group discussions and the in-depth interviews were fully transcribed. The tool "Amberscript" was used for this purpose, which complies with EU data protection regulations and was approved by the Ethics Committee (Amberscript, 2023). Furthermore, a non-disclosure agreement was signed with Amberscript. The transcribed text was qualitatively analyzed by means of Mayring's deductive category (2015). This is a specific qualitative content analysis approach used to structure qualitative data based on predefined categories. This approach uses a-priori evaluation categories that are established based on theory, allowing for content-related structuring (Mayring, 2015).

In this study, the category system was developed based on current fairness research theories according to Adams (1965); Bies (1986); Greenberg (1993); and Leventhal (1980) which were described above and consists of distributive, procedural, informational, and interpersonal fairness as the predefined main categories. The sub-categories, referred to as

Figure 4. Process of the Qualitative Data Analysis



Note. Process of the data analysis used in the main part of the study, using the qualitative content analysis, with a a-priori, deductive category system (Mayring, 2015).

subfacets, are defined in Table 4, with examples provided. The examples in this table are based on an application of the fairness facets to the context of aircraft noise issues (see Hauptvogel et al., 2021a). The focus group discussions and in-depth interviews were conducted in German and French, with the examples presented in this section translated into English.

Table 4. Deductive Category System

Fairness Facet	Subfacet	Description in the context of aircraft noise research
Distributive	Equity	The aircraft noise is distributed in a way that the ratio between the disadvantages and the benefits of the nearby airport are equal between all residents.
	Equality	Noise should be distributed equally over as many residents as possible, regardless of the composition of residents and other environmental strains.
	Need	Residents with special needs (e.g., children, sick or elderly) should be protected from the noise as much as possible.
Procedural	Process control	Residents have the opportunity to participate in decisions regarding aircraft noise management.
	Decision control	Residents can influence decisions regarding aircraft noise directly.
	Bias suppression	Decisions by the airport or airport stakeholders should not be taken solely for self-interest and economic reasons. For example, noise thresholds should be based on scientific knowledge of health effects.
	Representativeness	During all phases of decision-making procedures, the concerns and opinions of all affected citizens should be represented.
	Consistency	Procedures are consistent for every resident; nobody is given an advantage or disadvantage.
	Accuracy	The allocative process is based on sufficient, correct, and appropriate information. In this case, e.g., noise insulation schemes should be based on the most recent scientific data about the impact of noise on health.
Informational	Correctability	Opportunities exist to alter or reverse an inaccurate decision at various stages of a process. If decisions are made that affect the citizens concerned, they should be reconsidered and adapted accordingly in light of newer knowledge.
	Truthfulness	Communication with residents is based on honesty.
Interpersonal	Justification	Decisions are adequately explained to residents and the reasons for decisions are disclosed
	Propriety	Interaction with residents is characterized by respect and courtesy.
	Respect	Interaction is non-judgmental and courteous.

Note. Category system for the qualitative content analysis, based on research by Adams (1965); Bies (1986); Greenberg (1993); Leventhal (1980).

6.3. Results

The results will be presented in two sections. In the first section, the analysis of the main in-depth interviews and focus group discussions are presented (Research Question 1 and 2).

The second section focuses on the additional focus group discussion conducted to discern specific interventions that are desired from the perspective of noise affected residents (Research Question 3).

6.3.1 Sample description

In the first part of this sample description, the sample of the main study is described to answer Research Questions 1 and 2. In the second part, the smaller sample is presented, which describes the part of the study to validate the results and to answer Research Question 3.

Sample description of the main study

Table 5 shows the sample description of the focus group discussions and in-depth interviews to answer Research Questions 1 and 2. They represent the primary part of this paper. Four focus groups were conducted around Cologne-Bonn Airport, four more focus groups around Paris Charles-de-Gaulle Airport and 22 telephone interviews around Dusseldorf Airport.

Table 5. Sample Description of the Main Study

Variables	Cologne-Bonn Airport		Paris-Charles-de-Gaulle Airport		Dusseldorf Airport	
	Low exposure	High exposure	Low exposure	High exposure	Low exposure	High exposure
N	14	15	8	9	9	13
Gender	5 female	9 female	4 female	5 female	3 female	7 female
	9 male	6 male	4 male	4 male	6 male	6 male
Age m	48,7	47,3	45,0	44,0	68,8	60,4

Note. N = 68.

Sample of the additional focus groups

In November 2020, five online focus group discussions were conducted. The participants were residents living near Paris Charles-de-Gaulle Airport. The total sample consisted of 20 residents, with 12 females and 8 males, ranging in age from 21 to 63 years with an average age of 42 years. The sample was divided into four subgroups based on their place of residence (rural vs. urban) and their level of noise exposure (high > 60 dB L_{den} vs. lower ≤ 50 dB L_{den}). Additionally, a fifth group was formed with members of resident associations to ensure a comprehensive representation.

6.3.2 Fairness aspects from the view of affected residents

In the following section, the statements made by the participants in the focus group discussions and the in-depth interviews around Cologne-Bonn, Dusseldorf and Paris-Charles-de Gaulle Airports are assigned to the respective fairness facets and then discussed (Research Questions 1 and 2).

Distributive fairness

In this section, statements from noise affected residents of all three airports are assigned to the subfacets of distributive fairness, namely *equity*, *equality* and *need* (see Table 4).

The aspect of fairness in equity is most commonly referred to. Participants from both Dusseldorf Airport and Cologne-Bonn Airport highlight the proximity to the airport and the convenience of travel as key benefits of living close to the airport. Additionally, the airport is recognized as an important economic factor. One participant from Dusseldorf stated, *“If we ever fly away, (it is not that far) and I could well imagine that the airport is an economic factor.”* (high exposure group, Dusseldorf). In Cologne-Bonn, the residents stated the airport's relevance as an economic driver as well. For example, a resident of a highly noise-exposed region stated: *“I would be strictly against doing something against the airport. There are people who demand a ban on flights. [...] But in general, we depend on the airport for our living in the region.”* (high exposure group, Cologne-Bonn). Aside from the easy access to the airport, participants in Cologne-Bonn see the airport as a personal benefit, offering shopping opportunities on Sundays and public holidays when other shops are closed. They also see the airport as an attraction for families with children, providing a chance to observe aircraft taking off and landing.

However, participants raise a variety of disadvantages associated with living close to an airport and air traffic in general is mentioned as well.” *The negative is, of course, the aircraft*

noise.” (low exposure group, Dusseldorf). Further, air pollution due to air traffic is mentioned. It should be noted here that night flights are perceived as particularly burdensome around Cologne-Bonn Airport, due to a lack of night-flight restrictions. One resident shared the following argument: *“What I find particularly annoying are the cargo planes at 4 a.m., the old aircraft packed full trying to take off.”* (low exposure group, Cologne-Bonn). Participants complain about the lack of parking space, as passengers of the airport often park their cars in residential areas (*“In addition, there are problems for local residents caused by passengers, who park their car in the region”*; high exposure group, Dusseldorf).

Sound insulation schemes are viewed as positive and necessary, but simultaneously the airport should further support residents and provide more and better sound insulation. However, some participants view the aircraft noise as being more problematic when one is outside the house (*“Yes well, we have soundproof windows. But of course, that doesn't help if you want to enjoy the beautiful garden.”*; low exposure group, Dusseldorf). Noise protection measures (such as sound insulation) are classified here as distributive fairness, as this reduces the individual costs (the noise) and thus achieves a better distribution between costs and benefits, in accordance with the definition of distributive fairness (Adams, 1965).

To mitigate the impacts of noise pollution, two potential compensation measures were discussed among residents living near the Cologne-Bonn Airport. It was proposed that the airport could provide residents with two free flights per year⁴ and allow them to park at the airport without charge. From the perspective of the participants, this would at least somewhat compensate for the disadvantages of the airport in the region.

Aspects related to equality are only mentioned once both around Dusseldorf Airport and Cologne-Bonn Airport. In participants' opinion, the air traffic is already spread across different areas or flight routes are alternated to distribute the aircraft noise. Other participants think that the airport should focus more on the distribution of aircraft noise. *“And yes, you can certainly consider [...] whether you change the runways more often. They are often moved from one runway to the other. Then the take-off is further north, which is more pleasant for everyone in the south, and vice versa.”* (high exposure group, Dusseldorf). In Cologne-Bonn, participants observed that aircrafts follow different routes on different days. They perceive this as a deliberate effort to distribute the aircraft noise among residents. One participant from the low exposure group in Cologne-Bonn commented: *“And the following week, at the same time, the*

⁴ It must be noted that this proposal cannot be considered a long-term solution in the context of the climate crisis, but rather is perceived as a reasonable solution from the perspective of the participants.

same aircraft comes, but it is much further over there. There seems to be quite a variety of departure routes. I suppose it's a compromise: sometimes it's more of a burden on one group, sometimes it's more of a burden on another" (low exposure group, Cologne-Bonn).

Procedural Fairness

In the following, statements of noise affected residents are assigned to the facets of procedural fairness, namely *process control*, *decision control*, *bias suppression*, *representativeness*, *consistency*, *accuracy* and *correctability* (see Table 4).

Process control is mentioned repeatedly from the participants of all three airports. Whenever it is brought up, participants express dissatisfaction with the lack of engagement opportunities and transparency in decision-making processes. *"There's no communication, there's no transparency. It's not announced either. It's just done that way."* (high exposure group, Dusseldorf). *"You can start a "pseudo-dialogue" like that, but they're basically useless."* (low exposure group, Dusseldorf). Residents near Cologne-Bonn Airport express a sense that the airport is unapproachable and indifferent to the needs of the local community. They would like to see the airport provide opportunities for affected residents to engage in dialogue and exchange ideas. *"If focus groups like these could be arranged, why doesn't the airport do so? Where people can come together and voice their criticisms against the airport."* (high exposure group, Cologne-Bonn). Another resident commented, *"I would then feel that the airport has an open door and is making an effort to be a good neighbor."* (high exposure group, Cologne-Bonn). The residents emphasize the need for improved communication from the airport, suggesting that a citizen dialogue takes place twice a year. The aspect of proactivity is of particular importance to the residents. They should not have to fight for involvement, but rather, the airport should take the initiative to seek out their opinions. One resident emphasized the feeling of helplessness in relation to the airport and stressed that if residents were given a voice, less issues would be raised. *"I also see a lack of opportunity for citizen participation. [...] There's no one listening us! Only during elections, they all become active and make promises. [...] We all try to make an impact and our voices heard, but we are not listened to. You can make a point once, but three minutes later they've forgotten everything."* (low exposure group, Cologne-Bonn).

The aspect of decision control is closely linked to the process control aspect. Although it is not frequently mentioned, it has a negative connotation when it is brought up. *"Perhaps there should be a round table discussion. But everything is always decided somewhere in the city, single-handedly."* (low exposure group, Dusseldorf). In regard to decision control,

residents near Charles-de-Gaulle Airport point out that decisions are frequently made without considering the needs of the residents, including those with long-term impacts. *“They must have involved us in the decision for instance for the terminal four extension! The project is already fixed for 10 years without considering the real impact on our quality of life!”* (low exposure group, Paris-Charles-de-Gaulle). One resident acknowledged that the airport has limited responsibility for decisions, as many of them depend on various stakeholders such as the federal government, state government, local government, and airlines. Night flights at Cologne-Bonn Airport are, as mentioned previously, a key concern for residents. They are aware that decisions at the airport must balance the interests of various stakeholders. *“I understand that people work there and that people want to fly. I am part of the system myself. But it needs to be discussed openly and a solution needs to be found that takes everyone's interests into account and is followed.”* (low exposure group, Cologne-Bonn). One resident suggested that regular meetings should be held between affected residents and representatives of citizen initiatives, so that they can represent the needs of the residents at the airport.

The aspect of bias suppression is another issue raised by the residents with regards to the airport's practices. They contend that the airport does not provide impartial information and that airport expansions are executed without sufficient environmental impact assessments. This raises concerns about the prioritization of the economy over the environment, and the fairness of putting financial profit ahead of the quality of life of affected populations. The less impacted communities demand greater transparency and action to mitigate the negative effects of airport operations on their health and well-being. A resident from Paris-Charles-de-Gaulle Airport emphasized this point by stating, *“The airport always prefers the economic decision rather than the ecologic one, they never take into account the ecological issues in their decision.”* (low exposure group, Paris-Charles-de-Gaulle). This highlights the importance of fairness in considering the impact of airport operations on local communities and the environment.

The significance of considering the perspectives and needs of local residents into the decision-making process, the representativeness, is a recurring theme among participants. It is crucial to consider residents' needs and engage them in airport-related processes and decisions. *“I think, if the airport approaches (the residents) and that one mutually tries to understand the situation and the needs of the other, then (that would be good).”* (high exposure group, Dusseldorf).

The issue of consistency was raised by residents with regards to the airport's sound insulation scheme policy. *“However, within a street, for example, (one house gets the soundproofed windows and another house does not). Although they are just as annoyed, there*

were some limits or boundaries drawn. And I found that very unfair.” (high exposure group, Dusseldorf). Specifically, they express concerns regarding the enforcement of the night flight ban and limitations on airport expansion. *“We have a night flight ban, if I know correctly. [...] And there are exceptions constantly. When there are charter flights in the summer, the ban is somehow increased to 11 or 12 o’clock. I don’t think that’s good”* (low exposure group, Dusseldorf). Furthermore, residents living around Cologne-Bonn Airport expressed the need for consistency regarding the information provision online, as well as in the opportunities for their engagement in airport-related processes and decisions.

According to participants, the airport should measure the air pollution and regularly evaluate the protection zones in order to meet the fairness aspect of accuracy. *“These zones are also checked regularly. Not every week, but every 2 or 3 years to see if anything has changed.”* (high exposure group, Dusseldorf). Additionally, residents should be provided with accurate information about noise distribution, changes, and improvements being made at the airport, which is particularly relevant for property purchases and decisions. Furthermore, participants felt that the maximum nighttime exposure for aircraft noise should be redefined based on the findings of scientific human research, with the health and well-being of residents taking priority over economic interests in air traffic. Participants expressed their disbelief in the airport’s disregard for expert opinions which prove the harmful effects of night flights on health. *“For me, it is incomprehensible why the airport does not recognize these expert opinions?”* (low exposure group, Cologne-Bonn).

The concept of correctability was only indirectly referenced. Residents near the Cologne-Bonn Airport expressed their dissatisfaction with the night flights in the area and strongly advocated for a ban on them. This indirectly alludes to the idea of correctability, as the residents were well aware that they have no means to challenge or change this decision.

Informational Fairness

Thirdly, statements are assigned to the respective subfacets of informational fairness, namely *truthfulness* and *justification*.

Truthfulness is a recurrent theme among participants, who indicate a lack of informational fairness on the part of the airport. Some participants do not view information originating from the airport as impartial and truthful, but rather as being embellished by the airport to promote its own objectives. Residents living near Cologne-Bonn Airport have expressed their dissatisfaction with the fact that they are unable to obtain answers to their questions in a manner that is consistent with informational fairness. It is particularly striking

for residents that there is no ban on night flights at Cologne-Bonn Airport, which elicits confusion among residents who do not receive any explanations. One resident commented, *"How come Dusseldorf has a night flight ban and Cologne-Bonn Airport does not. I suspect or I fear that nothing will change in the foreseeable decades."* (high exposure group, Cologne-Bonn). Another resident emphasized the significance of open communication, stating, *"For me that would already be a neighborly relationship, if the other person answers me."* (high exposure group, Cologne-Bonn).

Another aspect relates to transparency. One resident noted, *"I think the airport is also a neighbor with closed doors, that's how it looks to me."* (high exposure group, Cologne-Bonn). This resident stresses that a fair, neighborly relationship could be established, if the airport was more transparent, if information was more freely available, and if there was a greater willingness to engage with noise affected residents. Residents living near Paris-Charles-de-Gaulle Airport have suggested the use of a mediator: *"We need some neutral mediator to communicate with us. Even if airport managers present data, we are not sure that this data is true."* (low exposure group, Paris-Charles-de-Gaulle). This highlights the issue of the airport not being perceived as truthful, and residents distrusting the airport's information and systematically questioning it. One participant noted that honesty could be a quick way to overcome this issue, *"This could be overcome relatively quickly if I feel that the airport [Cologne-Bonn] is telling the truth, the whole truth, and that it takes me seriously and sticks to agreements."* (low exposure group, Cologne-Bonn). Other participants added aspects that, according to them, are often overlooked, such as the airport highlighting the positive aspects of its operations. For example, one participant stated that noise is an inherent part of an airport and that it is important to acknowledge that thousands of rescue flights are also handled and that groceries are supplied that are bought in the supermarket every day. In this way, the positive aspects of the airport should be emphasized, thereby contributing to a more positive and complete picture of the airport.

Residents living near Cologne-Bonn Airport have criticized the airport's justification for allowing night flights, and have expressed the opinion that the decision should be explained in detail. *"I don't know what legal or other agreements there are. The fact that there is a ban on night flights in Frankfurt and Cologne can't manage it..."* *"In all these years, I have never once heard why a night flight ban is not possible in Cologne-Bonn. And that's where I have a problem"*. The airport is generally perceived as being uncommunicative. *"I would give it an "A" in compartmentalization."* (low exposure group, Cologne-Bonn). Residents suggest that the airport should be more proactive in reaching out to them and providing information about

its plans and decisions. *"What I miss is [...] that the airport approaches the affected residents and asks, "well, are you doing well? what do you think? We'll have an information event that day and we'll tell you what we're going to do and how terrible or how good it is"* (high exposure group, Cologne-Bonn). Further, it is important for contact persons to be adequately qualified to provide information. *"If you want to reach [...] someone, you never know if the person is even qualified to answer the question."* (high exposure group, Cologne-Bonn) The need for informational fairness to be established in the long term was emphasized by saying *"I think the airport has it really hard. I firmly believe that the airport is acting out of self-interest with its actions. The airport has to communicate with me in a very transparent way for a long time for me to believe that"* (low exposure group, Cologne-Bonn). Residents desire information about the night-flight-ban, noise protection zones, and flight routes. Information about the night-flight-ban and future plans are viewed as desirable as well as justifications on the noise protection zones (*"Whether (the zones are still correct)? "*; high exposure group, Dusseldorf) and the flight routes (*"Otherwise, the transparency of the airport in that direction is missing. Because there are definitely flight routes that are more bearable"*; high exposure group, Dusseldorf).

Interpersonal Fairness

Lastly, to answer Research Questions 1 and 2, statements are assigned to the subfacets of interpersonal fairness, *respect* and *propriety*.

Regarding interpersonal fairness, residents hold different perceptions. Some residents living around Cologne-Bonn Airport and Dusseldorf Airport view being responsive to neighbors as part of a fair and neighborly relationship. *"For me that would already be a neighborly relationship. If the other person replies to me."* (highly exposed group, Cologne-Bonn). This refers to the aspect of proactivity as well. One resident criticized that the airport is always pressured into action. *"It has to happen on its own initiative, not under pressure [...]. People complain to each other and that doesn't achieve anything, but the airport has to take care of it, it has a responsibility to take care of it!"* (high exposure group, Cologne-Bonn).

The obligation of the airport to care for residents due to the health effects of long-term aircraft noise is recognized by the residents as well. Residents in the Cologne-Bonn area particular see a ban on night flights as necessary in order to feel respected. *"There is a basic alphabet of decency. I would say that a ban on night flights and appropriate sleeping hours are part of that!"* (high exposure group, Cologne-Bonn). A resident formulated a respectful approach as follows: *"I think it's a nice idea to imagine that you really are a neighbor. Then*

you make sure that you can sleep at night alongside your neighbors or that you are considerate. If you throw a party, you inform them or invite them over." (high exposure group, Cologne-Bonn).

One participant sees no neighborly relationship between the airport and the residents at present. This is commented on by another participant: *"We knew when we moved here that the airport was here, we knew what we were getting into. You always have something [environmental pollution] somewhere. But regarding neighbors, I don't turn up my radio at night until the neighbor falls out of bed and then say that's not that bad, you'll get used to it. At least a period of five or six hours where there's really no noise, that would be great."*⁵(high exposure group, Cologne-Bonn). Another resident stated that he had the feeling that the fronts were hardened, but that there was a general willingness to cooperate: *"The attitude is partly hardened and also partly resentful. I think it's like talking in a marital dispute, the willingness to talk mitigates that a little bit. That is, of course, completely lacking."* (high exposure group, Cologne-Bonn).

Other residents, especially those with low levels of noise exposure, see noise reduction as the only viable option for dealing with each other in a respectful manner. *"A ban on night flights would be great, and perhaps the provision of sleeping quarters, so that they are sealed off somehow, so that you can sleep in peace."* (low exposure group, Cologne-Bonn). Residents around Paris-Charles-de-Gaulle mentioned that for now, the only strategy that was put forward by the airport is to relocate residents. However, it is a strategy that ignores the problem as opposed to solving it. Residents undoubtedly prefer strategies that aim at the source of the problem in order to tackle it. *"We, as citizens, are forced to be compliant, if we are not happy they will say move out"* (low exposure group, Charles-de-Gaulle). Another aspect refers to the parking situation that arises due to passengers. *"(Passengers) (use) [...] the parking space of the residents. Of course, the airport does not try to solve such things in any way by saying, okay, I'll create more parking capacity."* (high exposure group, Charles-de-Gaulle).

It is difficult to distinguish between the aspect of propriety and aspects that were previously assigned to the category of respect. Statements from participants refer to general aspects that participants describe as respectful interaction, for example *"What I miss, now that I think about it. If I want to be a good neighbor, then I am first of all friendly to people and talk*

⁵ It should be emphasized that even at airports where general night flights are prohibited, exceptions are still possible. At Frankfurt Airport, for example, a general ban on night flights has been established, but an annual average of up to 7.5 landings between 11 p.m. and midnight is still permitted.

to them. Family Day, making the airport open, showing how everything works. In fact, it's totally exciting what's happening there!" (low exposure group, Cologne-Bonn).

6.3.3 Results from the additional focus group discussions

In this section, the results from the additional focus group discussions around Paris Charles-de-Gaulle Airport are presented, conducted to validate the results from the main focus group discussions and in-depth interviews conducted at the three European Airports and to specifically ask residents about interventions to create a fair, neighborly relationship with the airport, answering Research Question 3.

In these additional focus group discussions, participants were specifically asked about interventions to establish a fair and neighborly relationship. It is important to note that these results are separate from the previously presented findings and serve to reinforce the conclusions from the first phase.

Participants affected by aircraft noise shared their ideas to enhance the relationship with the airport. The affected residents proposed concepts that integrate the fairness facets of distributive, procedural, informational and interpersonal fairness.

Residents prioritize appropriate interventions to address distributive fairness, focusing on reducing noise and implementing financial solutions to balance advantages and disadvantages. They seek a reduction in noise as a core element of fair and neighborly coexistence. Regarding compensation for noise, residents desire improved employment opportunities for young residents, affordable airport parking, flight discounts⁶, tax benefits, simplified noise abatement procedures (particularly in remote areas), and free medical examinations to assess noise and air pollution impacts.

Other aspects related to the airport's presence were also mentioned, including efforts to address traffic congestion, improve road conditions and public transport cleanliness, increase security with police presence, and enhance tourism in the airport vicinity (e.g., upgrading the airport shopping center to attract tourists).

There is a notable difference between the association group and the rural high-exposure group regarding noise distribution. The rural group believes that adding more flight routes to disperse noise would personally reduce annoyance, while the association group considers

⁶ As mentioned earlier, it must also be emphasized here that, within the context of the climate crisis, measures leading to an increase in flight movements cannot be considered a long-term solution.

reducing the number of people potentially affected by noise by decreasing flight routes to be more relevant.

Residents put forth ideas for interventions that align with aspects of procedural fairness. Some participants suggested establishing intermediary mediation services for local residents to facilitate processes that are considered fair by affected residents.

Residents expressed a desire for increased involvement in airport processes and the ability to communicate their wishes, views, and concerns. They proposed sharing their thoughts through questionnaires, surveys, polls, or direct contact in meetings with a neutral third party. They also recommended establishing organizational elements like users' committees, municipal representatives, general assemblies, and representation in airport decision-making. Involving the city and implementing interventions in schools, such as career forums and parent-child workshops, were also suggested.

The resident association group expressed additional viewpoints compared to other groups. They disagreed with the current measures, arguing that mere discussions are insufficient, and residents are not offered suitable job opportunities. Instead, they advocated for imposing stricter sanctions on airports or airlines that exceed noise limits and designated time frames.

Regarding communication and informational fairness, participants across all groups expressed a need for more information about health risks, pollution, and the airport's efforts to reduce noise impact. To address this, they suggested various communication channels, such as newsletters (both email and paper), websites, mobile applications, and monthly public meetings.

One common sentiment among all groups (rural, urban, and resident's association) was feeling excluded from discussions on airport noise exposure. They emphasized the crucial role of real information and complete transparency from the airport to foster inclusivity in the decision-making processes.

6.4 Discussion

The present qualitative study first analyzed the fairness aspects in the context of aircraft noise research from the perspective of residents. Furthermore, residents were asked how, from their point of view, a neighborly relationship could be established, with a focus on fairness-relevant aspects.

6.4.1 Discussion on Distributive Fairness

The aspect of distributive fairness plays a recurring role for the residents concerned in the focus group discussions and the in-depth interviews. Equity in the sense of the relationship between the cost or in this case disadvantages and the benefits from the airport in the region is a highly relevant topic from the perspective of the participants. There are also positive aspects that are associated with the airport in the region, such as the fast arrival time, the shopping opportunities or the important economic relevance in the region. However, most of the statements refer to the disadvantages living near an airport. For example, residents perceive the noise from the aircraft and the air pollution as negative aspects. Residents in the vicinity of Cologne-Bonn Airport see the noise during the night hours as particularly burdensome and unfair. Equality was mentioned only rarely by affected residents. However, it should be emphasized that residents around Dusseldorf Airport and Cologne-Bonn Airport are aware that the airport systematically varies the noise in order to reduce the impact on different residents at different times. However, this variation was hardly intended to distribute the noise among residents as an intentional act by the airport and is most likely a wind-dependent change of operating directions. The needs approach aspect was not mentioned by any of the participants. This may be due to the fact that the residents interviewed here, focus on their personal perceptions and their personal burden. The needs approach in this context would mean that residents who already have other sources of noise in the neighborhood or belong to a vulnerable group (children, the sick, the elderly) are especially protected from noise.

The results indicate that distributive fairness makes an essential contribution to the perception of fairness in the context of aircraft noise. Although the negative aspects predominate, positive perceptions were nevertheless expressed by the participants. It can be seen around Cologne-Bonn Airport, as well as at the other airports, that residents are aware of the relevance of the airport as an economic factor in the region and also of other positive aspects. As a negative aspect, night flights should once again be highlighted here, which are seen as particularly unfair by participants at Cologne-Bonn Airport. The aspects of equality and need are less strongly represented. Therefore, no statement can be made on the basis of this study as to which distribution of noise in the region is perceived as particularly fair.

In regard to potential interventions focusing on these aspects, two aspects should be highlighted. Firstly, efforts should continue to be made to mitigate individual noise exposure, especially at night. On the other hand, in the sense of establishing a fair cost-benefit ratio, ways should also be sought to compensate residents or municipalities for the burden the airport causes in regard to noise exposure. During the focus group discussions and in-depth interviews,

residents voiced their preferences for different compensation options. These suggestions offer a valuable chance to explore and refine these ideas, ultimately incorporating them into concrete intervention plans. For instance, rather than granting tax benefits to individuals, the airport could engage in supporting local projects or allocate financial resources to communities for free disposal services. It is essential to emphasize that such initiatives should not be seen as an attempt to "buy off" the airport's responsibilities towards the well-being of affected residents. Instead, they should complement efforts to alleviate the burdens and ensure a reduction in the overall impact on the community. It is essential to reiterate that the interventions discussed here represent ideas put forth by residents, with the aim of potentially improving the neighborly relationship with the airport, as seen from their perspective. This study does not assert that these interventions comprehensively address all the adverse health-related consequences of aircraft noise.

6.4.2 Discussion on Procedural Fairness

With regard to procedural fairness, the results here show the following picture. Although previous research (Leventhal, 1980) suggests a differentiation between process control and decision control, it holds a secondary significance for residents in this particular context. The primary concern for residents affected by noise was their general involvement in the decision-making process. Residents do not voice a clear distinction between participating in the process and actually influencing decisions at the airport. This lack of distinction may stem from the residents' perception of being currently excluded entirely from the decision-making process at the airport. It is possible that if they feel they are involved in the decision-making process, they pay more attention to whether their involvement is merely procedural or if they can genuinely impact the decisions. Regarding the airport's decisions, it is important to note that residents are well aware that those decisions are made based on the interests of multiple stakeholders. The residents have indicated the aspect of bias suppression, although it is more about decisions being made without considering the residents' quality of life. This bias suppression aspect is closely linked to both process and decision control, as it involves incorporating residents' concerns into the decision-making process. In the current context, accuracy refers to decisions being regularly evaluated based on new and correct information. Additionally, accurate communication of information is essential from the view of affected residents to perceive the airport as fair. This aspect can also be associated with bias suppression and is relevant to informational fairness as well. To summarize, residents perceive low levels of process and decision control across all airports. They view the airport as non-transparent, unapproachable,

and indifferent to the local community's needs. Proactivity plays a significant role in this context. Residents expect the airport to proactively engage with affected individuals and involve them in processes and decisions. The reason for this could be that the residents are constantly exposed to aircraft noise and therefore also expect the noise emitter to act. Residents emphasize their desire to be engaged and not presented with a *fait accompli*. They suggest focus group discussions or round table talks as suitable methods for involvement. Particularly, they stress the importance of being part of the decision-making process before final decisions are reached. Participation in decision-making is a top priority for residents, with a focus on ensuring procedural fairness by addressing bias suppression, representativeness, consistency, accuracy, and the ability to correct errors.

In regard to potential interventions derived from these results, residents suggest to establish an intermediary mediation service to facilitate fair processes and offer the ability to express their wishes, views and concerns (through questionnaire, surveys, polls or, more preferably through direct contact, assisted by a neutral third party). In terms of procedural fairness, they also highlighted the establishment of committees where different stakeholders are representing different groups in the decision-making process. These findings support prior qualitative studies seeing procedural fairness being important for residents (Liebe et al., 2020; Sommerfeld, 2013). Noise affected residents, especially in the vicinity of Cologne-Bonn Airport, are also demanding the possibility to revise what they consider to be wrong decisions on e.g. night flight. One possibility here could be to ensure that decision-making processes are made in accordance with a scientific advisory board to ensure that, for example, night flight permits are evaluated at regular intervals with regard to scientific findings on their effect on health. This also requires the possibility to revise decisions taken, which goes hand in hand with the aspect of correctability and accuracy, from research to procedural fairness (Leventhal, 1980).

6.4.3 Discussion on Informational Fairness

Informational fairness seems to be an important factor for residents. In contrast to the perspective put forth by Bies (1986), the current reality often involves an indirect interaction between the airport and residents due to noise-related impacts. However, it is crucial to acknowledge that residents genuinely wish for a direct and meaningful interaction, allowing for an exchange of information. Despite the prevailing indirect interactions in the current situation, there is a strong desire among residents to establish a direct channel for communication with the airport. This direct interaction would facilitate a more transparent and informative

relationship between the two parties. Furthermore, in the present context, informational fairness closely intertwines with procedural fairness. It revolves around the understanding that effective participation opportunities for residents can only exist if the information shared by the airport during these interactions is both truthful and transparent. Therefore, the aspects of informational fairness are intricately linked to the suppression of bias in procedural fairness. In this context, bias suppression refers to the airport making decisions not based solely on their own economic interests but in a fair and impartial manner. Regarding justification, it is essential for residents to be informed when airport decisions are detrimental to their well-being. Establishing a long-term, honest relationship and providing transparent information are crucial in this regard. Overall, the aspects of informational fairness play a significant role in cultivating a fair and neighborly relationship, serving as the foundation for building trust between the airport and the residents. The airport's lack of transparency and inadequate explanation of its decisions have created a perception of dishonesty among the residents affected by the airport. One particularly contentious issue is the night flights at Cologne-Bonn Airport, which significantly burden the local residents. These residents consistently express their frustration and inability to comprehend the necessity of these flights. They believe that a neutral mediator is essential to facilitate communication between the airport and the community. The residents' statements clearly indicate a lack of trust in the airport's actions, resulting in a general skepticism towards the information provided. Rebuilding this trust will undoubtedly require a considerable amount of time and effort. These findings align with the research conducted by Sommerfeld (2013), highlighting that residents desire comprehensive, transparent, and honest communication from the airport.

Based on the wishes and demands of the residents affected by noise, it can be said that the airport should provide information in an honest, direct and transparent manner in the future in order to establish a fair and neighbourly relationship with its residents. The results regarding the other fairness facets on distributive and procedural fairness indirectly demonstrate further that informational fairness is an important issue. For example, respondents repeatedly expressed incomprehension about noise protection regulations and emphasized that they did not know that there were contact points at the airport. A resident at Cologne-Bonn Airport pointed out that he did not know for sure whether and how a ban on night flights was established there. These aspects, assigned to other fairness facets, also underline the relevance of informational fairness in this context.

6.4.4 Discussion on Interpersonal Fairness

Interpersonal fairness at its core entails that the interaction between the parties involved is conducted in a respectful manner. Within the context of noise research, interpersonal fairness and general respect is closely tied to the notion of taking residents' needs seriously. In this regard, being proactive is crucial, as the airport should actively engage with residents and inquire about their situation. At Cologne-Bonn Airport, residents view the absence of a night flight ban as a concern in terms of respectful interaction. They hold the belief that implementing a night flight ban would be a respectful measure, considering the adverse impact of nighttime flights on their sleep. Residents draw a comparison between the airport and a considerate neighbor—one that genuinely cares about its neighbors, prioritizes their well-being, and treats them with respect. It is challenging to separate respect from propriety in this context, as it primarily reflects the airport's underlying attitude that shapes the principles of a fair coexistence.

In summary, we conclude that in distributive fairness, the aspect of equity is particularly relevant in the context of noise research. Here, residents perceive an imbalance between the disadvantages they experience and the benefits they notice from the airport. First, interventions to mitigate the noise from source would be essential to reduce the negative aspect of the airport. A provision of noise-free times, also called respite, could also be established in consultation with the affected residents. Here, arrivals and departures at the airport would be systematically varied in order to relieve some residents at certain times, while other residents would receive more noise during this time (Porter, 2017; Schreckenberget al., 2016).

The findings in this context extend previous research on interpersonal fairness. For example, affected residents see certain airport behavior as lacking respect, especially night flights at Cologne-Bonn Airport, and see a ban on night flights as a symbol of respect towards residents. Generally speaking, this means that the airport has to establish a respectful way of interacting with residents, which also requires genuine consideration in a sensitive manner.

6.5 Summary

To sum up, this paper thus fills an important gap in the research on non-acoustic factors by firstly highlighting the relevance of fairness in the context of aircraft noise annoyance management and describing the different fairness aspects with their respective characteristics from the residents' perspective. Few studies have directly surveyed airport residents about their perceptions, expectations and current views on neighborly relations with the airport. Sommerfeld (2013) qualitatively investigated the relationship between noise annoyance and

other variables such as attitudes and sense of community, and highlighted desires for change in the sense of a neighborly relationship with the airport. Furthermore, in another study residents were asked about measures they would like to see from the airport operator (Haugg et al., 2003). Based on this, a citizens' hotline was set up where residents affected by aircraft noise can contact the airport. The findings of these studies suggest that residents want an open and honest information policy (Haugg et al., 2003), characterized by mutual consideration and tolerance in combination with good communication. In the work of Sommerfeld (2013), residents expressed the desire for more information and explanations, which should also be provided in a comprehensible form.

The summary of the results under the aspect of fairness in connection with its subfacets distributive, procedural, informational and interpersonal fairness now offers the advantage that the concerns of the residents found can be given a name, which is already well researched in the field of psychological fairness research (for an overview, see Colquitt et al., 2001).

This qualitative study offers valuable insights into the actions required, according to the perspectives of affected residents, to foster a more amicable relationship with the neighboring airport. By delving into the experiences and viewpoints of those living in the vicinity of the airport, the research sheds light on potential measures and initiatives that could enhance a sense of community and improve interactions between residents and the airport. These findings not only contribute to a deeper understanding of the current dynamics but also offer valuable recommendations to promote a harmonious coexistence and address any existing challenges. As such, the study serves as a significant resource for stakeholders, policymakers, and airport authorities seeking to implement effective strategies to create a more neighborly environment for everyone involved.

6.6 Recommendations for a Fair, Neighborly Relationship

The surveyed residents mentioned a range of ways in which they believe a fair and neighbourly relationship can be established. In Table 6, these recommendations are summarized and concrete ways of implementing the recommendations are outlined. The recommendations mentioned here are also in line with fairness aspects as they can be derived from the literature (see also Hauptvogel et al., 2021a)

Such measures could help to mitigate the negative effects of aviation operations and reduce aircraft noise annoyance. Moreover, by promoting more open and transparent communication with local communities, airports can build trust and foster a sense of partnership with their neighbors. This, in turn, can lead to greater acceptance and support for airport

operations, and help to create a more positive and mutually beneficial relationship between airports and their surrounding communities. By following the recommendations outlined in Table 6, airports can take concrete steps towards creating a fair, neighborly relationship with the nearby communities.

Table 6. Recommendations for Fair Airport Management

Letter	Description	Implementation
F	Feedback: The airport should have an open ear for feedback from residents and address their concerns and complaints. It is important that residents feel heard and understood and facilitate open communication. Feedback from residents should be taken seriously and be able to revise decisions made if, after review, they are found to be wrong.	Establishment of a citizens' hotline or contact form to enable residents express their concerns, wishes and complaints, ensuring their feedback to be heard. One example could be Cologne-Bonn Airport, which allows under the term "Let's Talk!" to organize expert talks through video or telephone, answering questions concerning noise, noise protection and other relevant topics.
A	Active: The airport should actively seek residents' input and feedback.	Personalized letters, news provided via local radio and e-mail newsletters could inform affected residents about certain changes and ask for their opinion. Public participation could also be planned at regular intervals, for example in the form of open dialogue or focus group discussions, or periodic surveys.
I	Information Provision: Information regarding noise (changes) or future plans of the airport should be communicated timely, truthfully, directly and transparently to all affected residents. This is about telling the truth to all affected residents and not sugarcoating the details. Further, the information from the airport should be accurate and provide information on noise distribution, changes and improvements at the airport, especially regarding property purchases and decisions.	For example, an app could be created, a website or personalized newsletters. Furthermore, information provision in form of open meetings could be arranged. One example could be the Noise Platform provided by the ANIMA EU-Project, which offers transparent and understandable information regarding aviation noise, implementing a noise intervention and experience from other airports.
R	Respect: To build a fair and respectful relationship with the community, the airport operator should engage with community members in a respectful and considerate manner.	This includes engaging with community members in a respectful and open manner, acknowledging and addressing community concerns and complaints, and demonstrating a willingness to listen and learn from community feedback.
N	Noise Mitigation: Fairness also means that the airport should actively work to mitigate	The airport should consider the impacts of nighttime operations on nearby residents,

	noise impacts on nearby residents, recognizing that excessive noise can have negative health and quality of life effects.	recognizing that nighttime noise can have particularly significant effects on sleep quality and overall well-being. This may include implementing curfews, respite or restrictions on nighttime flights, or investing in noise-reducing technologies to minimize the impacts of nighttime operations.
E	Engagement: The airport should engage residents in meaningful dialogue and decision-making processes, recognizing the importance of building trust and fostering collaboration.	This may include establishing formal community advisory boards or committees, hosting regular public meetings and forums, or conducting surveys and other forms of community outreach. These involvement processes should be initiated before decisions are being made.
S	Sound Exposure Compensation: For many homeowners and residents, the negative impacts of aircraft noise can have significant financial consequences. The airport should ensure that the negative impacts on individual residents are compensated for.	To compensate for the disadvantages, measures could be taken, such as the airport's participation in local projects. Here, the municipalities in consultation with affected residents should decide how the money generated by the airport's profits is to be used.
S	Science: Decisions on noise distribution or noise protection zones should be updated at regular time intervals in the light of new scientific findings on the long-term effects of noise on health.	Noise protection measures at the airport must be evaluated transparently and impartially in order to ensure the protection of the population. To this end, processes at the airport must ensure that new findings from research are regularly incorporated into airport operations.

Note. Own table based on the results of the qualitative content analysis.

6.7 Strengths and Limitations

The present study has certain strengths and weaknesses.

Qualitative studies are often criticized for their relatively small sample size compared to quantitative studies, which limits their generalizability. However, the aim of a qualitative approach is typically not to achieve generalizability. Moreover, it should be noted that the quantifiability of the findings is a significant limitation in this study, as well as in most qualitative studies. This is due to the nature of focus group discussions, it was often challenging to determine the frequency of certain statements since they were discussed multiple times by different individuals, with others agreeing. Whether the results of qualitative studies are quantifiable or not is discussed frequently in qualitative research (Vicsek, 2010). A basic misconception that arises from quantification is the generalization of the findings to the general population (e.g. Morgan & Krueger, 1998). In the current paper we have adopted the

recommendation of Krueger (1994), who recommends that no quantification of the results should be carried out. The decision has the disadvantage that the results are not easy to interpret, as the relevance of aspects cannot be determined on the basis of numbers. Quantification would also have been problematic as it would not have illuminated how important individual aspects are. Aspects that were mentioned less often in terms of numbers could often be of enormous importance for affected residents, which is why a quantification might draw wrong conclusions. Moreover, the basic aim of qualitative studies, including the one presented here, is to gain a deeper insight into the thinking of the people concerned. We believe that quantification would distort the focus of this paper.

The participant selection process was carefully executed to ensure that individuals with significant exposure to aircraft noise, and where aircraft noise constituted the primary source of noise in the region, were included in the study. Additionally, data collection occurred at multiple airports in two countries with the intention of achieving a certain level of generalizability. However, it is important to note that currently, the results can only be applied to the study airports.

Since each airport possesses unique characteristics and situational conditions, further quantitative validation is required at a larger number of airports with a more extensive pool of test subjects to establish broader generalizability. Nonetheless, despite these individual differences, concerned residents at all airports consistently mentioned similar aspects related to cultivating fair and neighborly relationships with the airport, suggesting that fairness might be an important factor to all airport residents.

Another limitation of this study is the involvement of different interviewers or focus group discussion leaders in the data collection process. This may have introduced unconscious biases and prejudices that could have influenced the direction of the discussions. To ensure the objectivity of the research results in this study, all researchers strictly followed the discussion guideline that was prepared beforehand. To establish reliability, the categorization of statements was thoroughly discussed and transcripts were analyzed by two researchers followed by a discussion of the categorization. The categorization of statements into predefined categories was similar between researchers. Categorized statements were also checked by other researchers to ensure reliable classification.

This paper possesses a notable strength that deserves special recognition within the field of aircraft noise research. The study's distinctive approach is commendable for its constructive examination of the elements requiring modification to foster a fair and amicable neighborly relationship. Unlike previous research in this domain (e.g. Bartels & Müller, 2018), which has

predominantly centered on negative aspects, this paper offers a valuable contribution by adopting a more positive perspective, making it a valuable addition to the existing body of work in this area.

Another strength of this study lies in the established validity of the results, as they align with the categories proposed in theory. Previous research has highlighted the significance of procedural fairness in aviation noise research, which is consistent with the themes identified in this study (Maris, 2008). Similar themes have also emerged in other qualitative studies on residents impacted by aircraft noise (Sommerfeld, 2013).

A further significant strength of this study lies in its practical orientation. The action recommendations presented in Table 6 aim to be directly implemented in airport and aircraft noise management practices, with the goal of making a tangible difference in the lives of affected residents and improving their quality of life. However, it is essential to emphasize that the efficacy of these recommendations should be evaluated through systematic assessments and feedback from both residents and airport authorities. This evaluation process will help refine and optimize the proposed actions, ensuring their effectiveness and long-term impact on creating a more harmonious relationship between airports and the communities.

Moreover, the evaluation should also consider the potential effects of implementing fairness measures on various aspects, such as noise annoyance, acceptance, or even protest behavior among the residents. Understanding how fairness interventions can influence these factors will provide valuable insights into the broader implications of the proposed actions and aid in developing more comprehensive and targeted strategies for improving the overall airport-resident relationship.

6.8 Conclusion

In conclusion, this qualitative study aimed to gain insights into the experiences and perspectives of residents affected by aircraft noise in their respective regions, with the focus on fairness related aspects. The findings indicate that aircraft noise poses a significant burden for these residents. Participants from all three study areas expressed criticism towards the airport, specifically highlighting a lack of perceived fairness. This encompassed issues related to noise distribution, compensation for noise impacts, as well as opportunities for participation in processes and decisions. Additionally, residents emphasized the importance of proactive, transparent, and honest communication that is respectful and inclusive.

The findings from this study suggest that many previously researched non-acoustic factors such as trust, attitudes, predictability, and expectations could be influenced by aspects

of fairness (Sommerfeld, 2013). As can be seen from the discussions, attitudes towards the airport are not generally negative. Residents are aware of the airport's relevance and would not want to abandon the airport in general. However, it will take work to ease the partly hardened fronts and to establish a neighborly relationship.

The airport should strive to implement the action recommendations outlined here. It is essential to acknowledge that noise reduction still remains necessary, and effective communication alone cannot entirely eliminate annoyance among residents. However, fostering mutual understanding, improving acceptance, trust, and attitudes through fair communication can significantly contribute to mitigating annoyance and establishing a more positive airport-resident relationship in the long term.

Improved communication and noise reduction should not be seen as separate endeavors. Instead, fair communication should complement and support the ongoing technical efforts to reduce noise. An open and transparent dialogue between the airport and the affected residents can facilitate the development of collaborative solutions and address potential conflicts between noise reduction and quality of life in the airport region. By integrating both aspects, a long-term and sustainable improvement in the relationship between the airport and the community can be achieved.

7. Being a Fair Neighbor—Towards a Psychometric Inventory to Assess Fairness-Related Perceptions of Airports by Residents—Development and Validation of the Aircraft Noise-Related Fairness Inventory (fAIR-In)⁷

Abstract: Aircraft noise causes a variety of negative health consequences, and annoyance is a central factor mediating stress-related health risks. Non-acoustic factors play an important role in the experience of annoyance where the aspect of fairness is assumed to be a vital component. This paper describes the development of the Aircraft Noise-related Fairness Inventory (fAIR-In) and examines its factorial validity, construct validity and predictive validity. The development of the questionnaire included expert consultations, statements from airport residents and a large-scale online survey around three German airports (N = 1367). Its items cover distributive, procedural, informational and interpersonal fairness. Via mailshot, almost 100,000 flyers were sent out in more (>55 dB(A) L_{den})- and less (≤55 dB(A) L_{den})-aircraft-noise-exposed areas around Cologne-Bonn, Dusseldorf and Dortmund Airport. Thirty-two items were carefully selected considering reliability, theoretical importance and factor loading calculated via exploratory factor analysis (EFA), with all facets achieving high internal consistency ($\alpha = 0.89$ to 0.92). The factorial validity, analyzed via a confirmatory factor analysis (CFA), revealed that viewing distributive, procedural, informational and interpersonal fairness as distinct factors produced a better fit to the data than other categorizations with fewer factors. The fAIR-In shows adequate results in terms of construct validity and excellent results in terms of the predictive validity of annoyance by aircraft noise ($r = -0.53$ to $r = -0.68$), acceptance of airports and air traffic ($r = 0.46$ to $r = 0.59$) and willingness to protest ($r = -0.28$ to $r = -0.46$). The fAIR-In provides airport managers with a reliable, valid and easy-to-use tool to design, monitor and evaluate efforts to improve the neighborliness between an airport and its residents.

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7.1 Introduction

The harmful health effects of aircraft noise have repeatedly been demonstrated in a large number of studies and include a wide range of different effects from annoyance due to noise (Bartels et al., 2018; Guski et al., 2017), sleep disturbance (Basner & McGuire, 2018; Smith et al., 2022), increased risks for cardiovascular diseases (Babisch, 2014; Roca-Barceló et al., 2021; van Kempen et al., 2018), myocardial infarction (Babisch et al., 2005), hypertension (Dratva et al., 2012) and coronary heart disease (Roca-Barceló et al., 2021) as well as decreased mental health (Hegewald et al., 2020). Annoyance and disturbance due to noise (Guski et al., 2017) can be considered as one of the most important effects of noise. A detrimental effect has also been demonstrated in children that relates to health (Erickson & Newman, 2017), cognition (Klatte et al., 2017) and learning ability, e.g., through a decline in reading and oral comprehension (Klatte et al., 2013).

Even at low noise levels, perceived annoyance around airports is a widespread issue that manifests itself in cognitive, emotional and behavioral aspects (Guski et al., 2017). Annoyance is not only understood as an effect of noise, but can also be seen as a mediator between noise exposure and health risks (Babisch et al., 2013). It has been shown that people who describe themselves as highly annoyed are not only at higher risk for a variety of health issues, e.g., hypertension (Baudin et al., 2020) but also at risk with regard to aspects of mental health such as higher psychological distress (Baudin et al., 2018), depression (Benz & Schreckenber, 2019), the use of medication to treat anxiety disorder (Baudin et al., 2021) and a decrease in mental well-being (Schreckenber et al., 2017a).

The psychological model by Stallen (1999) suggests that noise annoyance can be seen as a stress response, and the degree of stress depends on the level of perceived control and the capacity to cope with the stressor—that is, noise in this context. Cognitive control has been seen as an important moderator of the impact of noise on behavior and health (Cohen & Spacapan, 1984). The evaluation of sound as unwanted and disturbing results in an activation of the sympathetic nervous system, resulting in a release of stress hormones such as cortisol and an increase in blood pressure (Babisch, 2002). If annoyance is seen as the psychological component of a stress response, it can be hypothesized that annoyance is associated with a variety of other negative stress-related physiological effects. A reduction in annoyance therefore seems to be an essential factor in minimizing the negative health-related consequences of long-term aircraft noise exposure. The evaluation of a sound as noise is highly subjective and depends on a variety of non-acoustic factors, such as attitudes, expectations, and situational

and personal factors (Bartels et al., 2018). As described above, the theoretical model by Stallen (1999) suggests that the stress reaction, here the degree of annoyance, depends on the possibility of coping with and control the stressor. Perceptions of psychological control and coping capacity depend, among other things, on how much one perceives trust in the authorities, how predictable such noise events are, whether one has any impact on the noise source, and on whether understandable information about the noise source is provided (Stallen, 1999).

Maris et al. (2007b) were the first to experimentally investigate the role of perceived fairness in the context of aircraft noise research and were able to show that a fair interaction is able to reduce the annoyance caused by noise in a laboratory setting, whereas an unfair procedure tested in an additional study by the same authors (Maris et al., 2007a) increases the annoyance caused by aircraft noise. Fairness can be seen as a major construct underlying many of these non-acoustic factors and has been reviewed in full detail by Hauptvogel et al. (2021a). Here, the aspects of distributive, procedural, informational and interpersonal fairness are outlined extensively and were applied to the context of aircraft noise according to theoretical principles.

In summary, the four aspects of fairness in the context of aircraft noise can be described as follows.

Distributive fairness reflects subjective perceptions of fairness in the distribution of resources among groups or individuals. Originally, it was assumed to be based on *equity*, a social comparison in the sense of a cost–benefit ratio (Adams, 1965). Adapted to the context of aircraft noise research, the *equity* rule suggests that aircraft noise should be distributed in such a way that the ratio between the costs (due to noise pollution) and the benefits that an airport brings to the region is shared equally between all residents. Leventhal (1980) introduced the principles of *equality* and *needs* as additional criteria for evaluating distributive fairness. In regard to the equality rule, aircraft noise should be distributed equally, i.e., among as many residents as possible, regardless of other factors (e.g., additional noise exposure from cars). The needs rule would suggest protection of vulnerable residents (e.g., children or elderly residents) from aircraft noise as much as possible, even if others are exposed to more noise as a consequence. As described in the review (Hauptvogel et al., 2021a), there is currently no clear answer for which of these distributions elicits the perception of being fairest in the noise-affected residents. Nevertheless, the view of noise as a distributively unfair state offers starting points for interventions to re-establish a balance between cost and benefit or to approach this balance; (see Hauptvogel et al., 2021a).

Research on procedural fairness suggests that the process leading to a distribution is at least as important in the experience of fairness as the outcome itself. In the context of aircraft noise, this suggests that the process leading to decisions at the airport is a key determinant in how fairly the distributions of noise are experienced. In their research on procedural fairness, Leventhal (1980) developed a set of criteria that constitute a fair process. Applied in the context of noise research (Hauptvogel et al., 2021a), these include *representativeness*, which means that the concerns and opinions of all affected parties should be represented at each stage of the decision-making process. The *consistency* rule states that procedures are consistently applied across all residents and times and the *bias suppression* rule specifies that decisions at the airport are not made on the basis of self-interest but rather from an inter-subjective or non-partisan perspective. The *accuracy* rule suggests that decisions are made on the basis of correct and appropriate information and the *correctability* rule proposes that there are also opportunities to revise incorrect or inaccurate decisions. The *ethicality* rule states that processes generally adhere to fundamental ethical and moral standards.

In addition to issues of distributive and procedural fairness, research also indicates that the interaction between the involved parties plays an equally important role in the final perception of fairness (Bies & Shapiro, 1988; Greenberg, 1993). This so-called interactional fairness comprises informational fairness on the one hand and interpersonal fairness on the other (Bies & Moag, 1986). It is not sufficient to simply give affected people the opportunity to voice their opinion during the decision-making process; instead, fairness also depends on how the decisions are eventually communicated to these people and how this personal interaction is perceived.

Interpersonal fairness, adapted to the context of aircraft noise research, describes the degree to which aircraft noise-affected residents are approached with respect, dignity and kindness by airport authorities. Informational fairness describes how well decisions regarding aircraft noise are explained to those affected and includes aspects of honesty, transparency and justification. Regarding informational fairness, a number of studies have shown that residents living near airports would like to see more honest, transparent and comprehensive as well as understandable communication in order to establish good neighborliness with the airport (Maziul & Vogt, 2002; Sommerfeld, 2013).

As outlined above, individual perceptions of fairness can have an important influence on residents' attitudes towards the airport and, thus, are assumed to establish a foundation of trust in the long term. A first attempt to develop a psychometric questionnaire of fairness in the context of aircraft noise was undertaken by Bartels (2014). However, due to a very small sample

size, further research was needed. Therefore, a reliable and valid measure of perceived fairness in regard to noise distributions at airports is still missing up to now. We aim to fill this gap by developing a measure of perceived distributive, procedural and interactional fairness in the context of airports.

The present paper has three main objectives with three key benefits:

First, the development process of the fAIR-In is presented, which involved item development and a large-scale study with residents of three German airports to validate the instrument. The results allow researchers to further explore the aspect of fairness in relation to noise annoyance and potential other negative health effects of noise.

Secondly, the factorial validity of the questionnaire is examined by comparing one-factor, two-factor, three-factor, and four-factor solutions to test whether the found factor model of fairness proposed by Colquitt (2001) is also applicable in the context of aircraft noise.

Finally, the construct and the predictive validity of the fAIR-In are investigated to determine whether the fairness facets measured predict residents' responses to local aviation and aircraft noise management, such as aircraft noise annoyance, acceptance of air traffic and protest behavior against the airport. The results of this analysis provide insight into the effectiveness of the fAIR-In as a comprehensive tool for airport managers, airport authorities and researchers to design, monitor and evaluate efforts to improve relations between residents and the airport.

7.2 Materials and Methods

7.2.1 Sample

We conducted a cross-sectional online study around three German airports in Cologne-Bonn, Dusseldorf and Dortmund. The study procedure was approved by the ethics committee of the Medical Association of North Rhine with the consecutive number 2019235 on 17 May 2021. These regions were chosen to include airports with different characteristics regarding the number, type and timing of operations. At Cologne-Bonn Airport, night flights with predominantly cargo flights are allowed. In contrast, at Dusseldorf Airport, which is a major German hub airport, night flights are restricted between 10 p.m. and 6 a.m. In contrast to the other two airports, Dortmund Airport is a comparatively small regional airport with a lower number of flights and a ban on regular night flights between 11 p.m. and 6 a.m. Through the choice of airports, different characteristics are covered, providing a comprehensive picture of the perception of fairness under different noise conditions.

The study regions were carefully selected around the airports to include residents experiencing higher aircraft noise exposure (>55 dB(A) L_{den}) and residents affected by comparably lower exposure (≤ 55 dB(A) L_{den}). The regions were selected in such a way that aircraft noise was the dominant noise source and both urban and rural regions were represented. Noise exposure was estimated on the basis of the freely available environmental noise maps provided by the state of North Rhine Westphalia from the Ministry for the Environment, Nature Protection and Transport (Ministerium für Umwelt, 2017). These freely available noise maps were produced for noise action planning according to the EU Directive 2002/49 on the assessment and management of environmental noise (EU, 2002).

For the recruitment of participants, we invited participants using mail flyers. Delivery districts were assigned to the identified regions with the help of a mail distribution system, the Postaktuell Manager of the German Post (Post, 2022). Flyers containing a link to the survey were sent to every household within these regions.

Two identical questionnaires were programmed in the survey software used, one for the more- and one for the less-exposed areas. Flyers sent to eligible test areas either contained the survey link for the more-exposed areas or for the less-exposed areas. Participants from areas with higher exposure to aircraft noise received exactly the same questionnaire as participants from areas with lower exposure to aircraft noise, but the different links made it possible to assign survey data to the different noise exposure levels.

The flyers contained information about the study and a link to participate. Furthermore, $10 \times 100\text{€}$ were raffled between all participants, which was pointed out on the flyer. Studies have shown that the likelihood to participate is highest when there is a financial incentive and the invitation is framed in a personalized manner that emphasizes the individual importance of each participant's contribution (Göritz, 2006; Pedersen & Nielsen, 2016). Participants had the option to take part in the study online through the link provided or to receive a postal version of the questionnaire by calling or e-mailing.

A total of 99,921 flyers were sent out in September and October 2021. Of these, 44,134 were sent to areas with high noise exposure and 55,787 to areas with lower noise exposure. It was assumed that the willingness to participate would be lower in the less noise-exposed areas due to their larger distance from and probably less relation to the airport and its air traffic. Moreover, since exposure is lower, the level of suffering due to noise and the feeling of being affected by (un)fair noise-related decisions were also assumed to be decreased.

A total of 1733 people from the high-exposure areas and 1128 from lower-exposure areas took part. After sorting out discontinued or incomplete entries, there were still a total of

1367 people, 840 from highly exposed regions and 527 from less-affected areas. In total, 1.9% of the more highly aircraft-noise-exposed residents who received a flyer completed the survey and 0.9% of the people who had a lesser exposure to aircraft noise completed the survey. The average completion rate across both noise exposure areas was 1.37% (see Table 7 for an overview).

Table 7. Response and Completion Rate according to Noise Exposure Levels

	Higher Noise Exposure	Lower Noise Exposure	Total
Response rate	3.93%	2.02%	1.73%
Completion rate	1.90%	0.90%	1.37%

Separated according to airports, the following pattern emerges.

- Cologne-Bonn Airport: 51,864 flyers sent out, 1721 responses (3.3%) and 819 fully completed survey (1.6%).
- Dusseldorf Airport: 39,794 flyers sent out, 946 responses (2.4%) and 454 fully completed the survey (1.1%).
- Dortmund Airport: 7694 flyers sent out, 194 responses (2.5%) and 91 fully completed the survey (1.2%).

Looking at these distributions, it is evident that there was a very low participation rate across all airports. The slightly higher proportion at Cologne-Bonn Airport could be attributed to the fact that night flights play a special role at this airport that is perceived as particularly annoying.

7.2.2 Fairness Items

The items for measuring fairness-related perceptions in the context of airport management were developed in three different ways. Firstly, a critical incident technique was conducted with scientific experts from the field of aircraft noise research and airport authorities (Flanagan, 1954). They were asked about their personal experience in dealing with angry and upset residents and critical incidents in which specific situations were identified. The accusations against the airport and general triggers gave an insight into typical, fairness-related situations that could be used to develop a first set of items. Secondly, the items were derived from research in the literature and existing measurement instruments from other domains, especially organizational psychology (Bies, 1986; Leventhal, 1980; Thibaut & Walker, 1975). Finally,

affected residents living around airports were interviewed in focus groups, which resulted in further items. These focus groups were conducted as part of the EU project ANIMA investigating, among other things, how a neighborly relationship to the airport can be developed (Hauptvogel, 2021).

The classification of facets and subfacets was based on previous research. With regard to the facet of distributive fairness, the subfacets *equity* (Adams, 1965), *equality* (Leventhal, 1980) and *need* (Leventhal, 1980) were adopted. For the facet of procedural fairness, the subfacets of *representativeness*, *consistency*, *bias suppression*, *accuracy*, *correctability* and *ethicality* were derived from research of Leventhal (1976). With regard to the facets of informational and interpersonal fairness, the subfacets of *truthfulness*, *justification*, *respect* and *propriety* were taken from the work of Bies (1986). *Empowerment* was included as an additional subfacet to the facet of informational fairness. This subfacet reflects whether and how the airport (a) empowers residents to discuss on an equal level, (b) provides contact points for further information, and (c) makes the general information transfer low-threshold. The aspect of empowerment was suggested in the focus groups (Hauptvogel, 2021) as a relevant aspect of how residents imagine a fair, neighborly relationship. In the “Vienna Dialogue Forum”, the significance of empowerment as a crucial non-acoustic factor was discussed (Heyes et al., 2022; Heyes et al., 2021). Empowerment has been classified as a subfacet of informational fairness, as it is mainly reliant on the quality of information regarding comprehensiveness and comprehensibility provided by airports. In contrast to truthfulness and justification, it focuses on enhancing residents’ abilities to express their concerns by providing them with accessible and understandable information on various aspects of the airport and the local air traffic.

A total of 68 items were developed and categorized into the facets of distributive fairness, procedural fairness, informational fairness and interpersonal fairness with their respective subfacets and were randomized in the online questionnaire to minimize sequence effects. The complete questionnaire with instructions and evaluation instructions can be found in the Supplementary Material, both in the original German language (Table A.20) and translated into English (A.21)

A pretest with 22 persons was conducted with employees of the German Aerospace Center e.V (DLR). This provided the opportunity to give concrete feedback concerning difficulties in understanding individual items or tasks. By maximizing internal consistency at the subfacet level, a total of 29 of the original 68 items were excluded. Care was taken to exclude redundant items or items that were comparable in regard to their primary statement, as well as items that did not follow the original idea from the literature and/or had high numbers of omitted answers.

Another seven items were eliminated after an additional factor analysis in which the factor loadings of items to the respective fairness facet were investigated as described in Section 7.3.2. A total of 32 items remained in the fAIR-In.

Table 8 provides example items of the final questionnaire representing the four fairness facets (distributive, procedural, informational, and interpersonal fairness) and their subfacets. It is crucial to highlight that while the items were chosen to signify the subfacets (such as equity, equality and need) of their respective fairness facets, it is not asserted that these aspects are measured with sufficient reliability and validity due to the anticipated high correlation among the subfacets. Despite the improvement in measurement economics when reducing the number of items, the loss of insight would be detrimental to the informative value of the fAIR-In.

Table 8. Example Items of the fAIR-In

Fairness Facet	Subfacet	Item Example
Distributive Fairness	Equity	The airport brings me more advantages than disadvantages.
	Equality	Due to the different approach and departure directions of the aircraft, the noise pollution is evenly distributed among the residents.
	Need	The approach and departure directions are set in such a way that those in need of protection, such as children or sick people, are affected as little as possible by aircraft noise.
Procedural Fairness	Process Control	Before decisions are made on aircraft noise, I have the opportunity to make my views known to those responsible.
	Decision Control	When decisions are made about aircraft noise, I can influence the outcome of the decision-making process.
	Bias Suppression	The airport attempts to make decisions in an unbiased and neutral manner.
	Representativeness	All parties who are affected are involved in decisions relevant to aircraft noise.
	Consistency	Residents cannot understand why different rules apply at different airports, e.g. on night rest times or flight bans.
	Accuracy	In the decision-making processes, those responsible often make decisions on the basis of incorrect information.
	Correctability	I have the possibility to take action against decisions that I think

are wrong.

Informational Fairness	Truthfulness	The airport is honest about its plans for the future.
	Justification	The airport explains and justifies decisions relevant to aircraft noise in detail.
	Empowerment	The airport provides information that enables residents to discuss with airport authorities on an equal footing.
Interpersonal Fairness	Propriety	The airport strives for an exchange with noise-affected residents that is conducted at eye level.
	Respect	The exchange between the airport and local residents is respectful.

Note. The response scale was a 5-point scale with response options (1) not true, (2) a little true, (3) moderately true, (4) quite a bit true and (5) very true.

7.2.3 Scales to Test Construct Validity

Construct validity indicates the extent to which the measured value of a scale is suitable as an indicator for the characteristic that is to be assessed. It therefore describes the validity of a measurement instrument. This means that if the fAIR-In proves to be construct-valid, it truly measures these fairness facets in relation to the airport in the region. According to Campbell and Fiske (1959), a distinction should be made between convergent and divergent validity to determine construct validity.

Convergent validity means that correlations are determined between different tests that measure the same or a construct-like construct. The correlation should be as high as possible for a valid test. According to Cohen (1992), a small effect is present from $r = 0.10$, a medium effect from $r = 0.30$ and a strong effect from $r = 0.50$.

Divergent validity measures the correlations between different tests and instruments that measure different constructs. Here the correlation should be low or non-existent. According to Cohen (1992), a small effect can be considered at $r = 0.10$.

An overview of all additional scales for measuring construct validity can be seen in Table 9. The response scale of all additional measures was a 5-point scale with the response options (1) not true, (2) a little true, (3) moderately true, (4) quite a bit true and (5) very true. The present response categories were chosen to correspond to an interval level, since the response categories are equally spaced (Fields et al., 2001; Rohrmann, 1978). Since there is no established questionnaire that measures fairness in the context of aircraft noise management, no empirically

validated relationships could be pre-determined to be tested. For this reason, correlations between the scales and the various fairness facets are calculated and the relationships analyzed.

Table 9. Additional Scales to Test Construct Validity

Scale	Source
Interpersonal Trust (KUSIV3)	Beierlein, Kemper, Kovaleva, and Rammstedt (2012b)
Political Confidence and Influence Perception (PEKS)	Beierlein, Kemper, Kovaleva, and Rammstedt (2012a)
Sensitivity to Injustice (USS-8)	Baumert, Beierlein, and Schmitt (2014)
Perception of control (IE-4)	Kovaleva, Beierlein, Kemper, and Rammstedt (2012)

Trust is an important component of interpersonal interaction. The KUSIV3 scale measures an individuals generalized expectation of being able to rely on the words and promises in the form of oral or written statements of others or a group (Amelang, Gold, & Külbel, 1984). It, thus, describes the individual level of the personality trait of trust in an interpersonal context. For this reason, we expected a positive correlation between interpersonal trust and fairness aspects, especially with interpersonal fairness. A high level of interpersonal trust could lead to residents perceiving the airport and intentions as more positive and therefore lead to residents being more likely to perceive the various fairness criteria as fulfilled.

The political efficacy short scale (PEKS) is used to measure individual political competence and influence beliefs (Campbell, Gurin, & Miller, 1954) and describes the belief that one can understand and influence political processes (Vetter, 1997). It is considered the most important predictor of political participation. Internal political efficacy, a part of the PEKS, refers to the individuals self-belief that they have political power to participate (Niemi, Craig, & Mattei, 1991). We expected a positive correlation between internal political efficacy and fairness aspects. If residents report high scores in internal political efficacy, then it means that they have more confidence in their ability to actively participate in political decisions and processes. This active, political engagement could lead to actually noticing measures by the airport and, consequently, perceive the airport as fairer.

External political efficacy, the second half of the PEKS, on the other hand, defines the individuals belief that authorities or systems are susceptible to attempts to influence them. External political efficacy, thus, describes the conviction regarding the political system and is

associated with trust in political institutions. If people perceive a generally high external political efficacy, they may also perceive higher values in the fairness aspects, above all with regard to possibilities to interact with airport authorities and to voice their needs and concerns, thus influencing the decisions made by airport authorities.

The USS-8 scale measures the personality trait that describes how one individually experiences and responds to injustice. The construct of injustice sensitivity reflects the disposition of how easily people perceive injustice and how strongly they react to it (Schmitt, Baumert, Gollwitzer, & Maes, 2010b). These interindividual differences are stable and can be generalized across unjust situations. A distinction is made between four perspectives: the victim, the observer, the beneficiary and the perpetrator perspective. The four perspectives can help explain social phenomena such as the willingness to protest politically, altruism and civility (Rothmund et al., 2014). We expect that people who are more sensitive to injustice will also perceive the airport as less fair. In particular, residents living near the airport with high levels of victim sensitivity might be particularly sensitive to aircraft noise, as they feel they are victims of inequitable noise pollution. The locus of control (IE-4) personality trait derives from social learning (Rotter & Hochreich, 1979) and distinguishes between internal and external control beliefs. Internal locus of control describes the extent to which an individual is convinced that they can control events and the extent to which this is experienced as a consequence of their own behavior, whereas external locus of control is associated with viewing events as fate, chance or under the control of powerful others over which they have no influence (Levenson, 1973). We expect a positive relationship between internal locus of control and the different facets of fairness. People with an internal locus of control tend to see themselves as active actors who are able to influence the situation. They might actively participate in participation processes or look for ways to reduce or minimize aircraft noise.

Individuals with an external locus of control, on the other hand, may be more inclined to see themselves as victims of circumstances beyond their control. They may be less committed or more likely to seek compensation or support from others. For this reason, we assume a negative correlation in relation to perceptions of fairness.

Political cynicism can be seen as an attitude and subdimension of political disaffection or disenchantment with politics and is understood as a lack of support for the political system (Arzheimer, 2005). However, this dimension does not refer to the whole system in general, but describes the skepticism and distrust towards the current political authorities and therefore reflects the opposite of trust in authorities. Individuals with high levels of political cynicism could be skeptical about the airport and its actions, feeling that processes are unfair and that

residents' interests are not adequately considered. For this reason, we expect a negative correlation between political cynicism and the fairness aspects.

However, since none of the scales mentioned above assesses constructs that are exactly the same as fairness or even very similar, all correlations between the mentioned scales and the fairness facets are assumed to be very to rather low (around $r = 0.10$) according to Cohen's convention (1992).

7.2.4 Criterion Variables to Test Predictive Validity

Predictive validity is the accuracy with which a psychometric questionnaire is able to predict what it is intended to predict (Lienert & Raatz, 1998). Since this is a cross-sectional study, no directional relationship can be established; therefore, a high correlation between the constructs and the fAIR-In serves as a measure of predictive validity.

Since the fAIR-In is intended to be relevant in the context of aircraft noise research, aircraft noise annoyance, acceptance of the airport and air traffic, and willingness to protest are seen as important variables to validate predictive validity, and their relationship with the various fairness facets is examined, as seen in Table 10.

Table 10. Additional Scales to Test Predictive Validity

Scale	Source
Aircraft Noise Annoyance	Fields et al. (2001)
Acceptance of Airport and Air Travel	Adjusted from Quehl and Basner (2006)
Protest Behavior	Adjusted from Schreckenber, Eikmann, Herr, zur Nieden, and Heudorf (2009)

It is assumed that the higher the perceived fairness, the lower the perceived aircraft noise annoyance, as well as the willingness to protest. It is also expected that perceived fairness is positively associated with the acceptance of the airport and air traffic.

To measure predictive validity, scales were used to measure aircraft noise annoyance (5-point IC BEN Question according to ISO/TS 15666) (Clark et al., 2022): a scale to measure acceptance of the airport and air traffic and a scale to measure willingness to protest.

The question to assess the noise annoyance is "Thinking about the last 12 months, when you are here at home, how much does noise from aircraft bother, disturb, or annoy you?".

The acceptance scale was already used in previous studies conducted within DLR (Quehl & Basner, 2006) and was adjusted to this study. It includes a number of aspects related to the airport and air traffic that participants are asked to assess. Specifically, it asks how necessary, dangerous to human health, unsafe, harmful to the environment, avoidable, bad for air quality, harmful to the climate and reasonable the airport and air traffic are. Here, the mean value of the items was formed after the negatively formulated items were transformed. The internal consistency of this scale is high ($\alpha = 0.87$). See Table A.23 for the complete scale in the original language as well as the English translation. Willingness to protest is also a scale that has already been used in previous internal studies (Schreckenberget al., 2009) and was adjusted to this study. It was asked if a protest list, petition or similar had been signed, whether contact had been made with the airport or a responsible office to obtain information or to complain, whether a citizens' initiative against aircraft noise had been joined, whether a demonstration had been attended or whether people had moved to another region because of the aircraft noise or whether a move was being considered. The internal consistency of this set of questions is acceptable ($\alpha = 0.70$). See Table A.24 for the complete scale in the original language as well as the English translation.

7.2.5 Further Questions

To check whether participants were clicking on the answers at random, attention checks were included in the questionnaire. In total, three questions were added, asking participants easy multiple-choice questions, such as which city is the capital of Germany, or choosing between potential results for adding seven plus three.

7.3 Statistical Analysis

7.3.1 Data Cleaning and Preparation

Out of a total of 2872 participants who started the questionnaire, 1505 incomplete datasets were excluded from further analyses (52.40%). Of these, 1406 of the 1505 incomplete datasets were individuals who quit the questionnaire before completing it and did not save their answers.

All items of the questionnaire were mandatory questions. This means that one could not continue the questionnaire if a question was skipped. The fairness questions, on the other hand, were designed in such a way that it was possible to skip individual items. If this happened for one of the fairness questions, the participants were informed that one or more answers were

missing and had to confirm that this was intentional. Otherwise, they had the opportunity to re-enter missing answers in the fairness items.

Among the 99 people who completed the questionnaire but had missing values in the fairness questions, 26 people had to be excluded. The criterion for this was omission of more than half of the items per subfacet (e.g., equity, equality). Another 73 people who had less than half of the missing items per subfacet were also eliminated for the subsequent calculations, as the maximum likelihood estimation method for the confirmatory factor analysis can only handle complete datasets (Rosseel, 2012). However, they were included in the selection of final items to help discard items that had similar characteristics. This led to a total of 1367 complete datasets (47.64%).

The dataset of fully completed questionnaires was randomly divided into two separate parts. The two separate datasets (Dataset A and Dataset B) could, thus, be used for independent calculations and prevent overfitting (Fokkema & Greiff, 2017).

7.3.2 Item Selection

Item selection was performed in several steps within Dataset A. First, scales were created for the respective fairness facets (distributive, procedural, informational and interpersonal fairness) and the respective subfacets (e.g., equity, equality, need for distributive fairness and process and decision control, etc., for procedural fairness) according to the most recent fairness literature (see Colquitt, 2001). A separate reliability analysis was carried out for each subfacet and further items were excluded, which resulted in an increase in the internal consistency of the scale. This was performed for each subfacet until no more improvement could be achieved. Both Cronbach's alpha and McDonald's omega were calculated to check internal consistency. McDonald's omega (ω) values are more robust and recent research shows that these values should be reported rather than Cronbach's alpha (α) (Ravinder & Saraswathi, 2020). However, since no significant differences were found, the traditional Cronbach's alpha (α) is reported below.

Generally, when excluding items, attention was also paid to the item difficulty in order to minimize floor or ceiling effects (Krüger, Parchmann, & Schecker, 2014).

After aiming for a number of two to three items per subfacet, in order to reduce the redundancy and enhance the efficiency of the questionnaire, a factor analysis was calculated. Additional items were removed according to three criteria postulated by Tabachnick, Fidell, and Ullman (2007) (see also Costello & Osborne, 2005). The first criterion suggests the exclusion of items with a factor loading below 0.32 on any factor. Secondly, items were

removed that had loadings exceeding 0.32 on more than one factor. Lastly, it was ensured that factors had at least five items with factor loadings over 0.5. Only highly relevant items were retained in the final fAIR-In, even if they did not meet these criteria. At the end, the fAIR-In included 32 items.

7.3.3 Factorial Validity

In order to test factorial validity, we calculated confirmatory factor analyses (CFAs) using Dataset B. The “lavaan” package was used in RStudio (Version 1.3.959) for this purpose (Rosseel, 2012). This package provides robust estimates with Santorra–Bentler correction for the maximum likelihood (ML) procedure. The ML estimation with Santorra–Bentler correction should be preferred to other estimators that can handle non-normal data, such as the asymptotically distribution-free estimator (ADF) (Browne, 1984). ML is superior to other estimators because it is more stable, more accurate and has a higher precision in terms of empirical and theoretical fit (Olsson, Foss, Troye, & Howell, 2000).

Four different models were compared to each other as seen in Table 11. Model 1, the four-factor model, distinguishes between distributive, procedural, informational and interpersonal fairness as proposed by Greenberg (1993). Model 2, the three-factor model, distinguishes between distributive, procedural and interactional fairness, subsuming the aspects of informational and interpersonal fairness under one factor as suggested by Bies (1986). In Model 3, the two-factor model, distributive fairness and procedural fairness are assumed, in which the aspects of informational and interpersonal fairness are combined into the procedural fairness as seen in Niehoff and Moorman (1993). Model 4, the one-factor model, comprises all items under the aspect of a superordinate perception of fairness, as researched by Colquitt (2001).

Table 11. Facet Division for Each Model

Model	Facets
Model 1 (4 Factor solution)	Distributive, Procedural, Informational, Interpersonal
Model 2 (3 Factor solution)	Distributive, Procedural, Interactional
Model 3 (2 Factor solution)	Distributive, Procedural
Model 4 (1 Factor solution)	Overall Fairness

Since some subfacets contained only a few items and, even more relevantly, correlated very strongly with each other in some cases, they were not modeled separately in an additional level within the confirmatory factor analysis.

7.4 Results

7.4.1 Sample

Table 12 describes the sample. A total of 1367 complete data sets were collected. The randomized division of the complete data set into data set A and data set B shows that the characteristics of the sample are equally represented in both parts and that they do not differ noticeably from each other. The educational levels surveyed based on the German education system were converted to the international standard classification of education (ISCED-2011) (UNESCO, 2012). An overview of the sampling characteristics for the various airports can be found in Table A.17).

Table 12. Sample Description divided into Dataset A and B

	Dataset A	Dataset B	Total
Total	691	676	1,367
	N (%)	N (%)	
Gender			
Male	409 (59.2)	399 (59)	808 (59.1)
Female	279 (40.4)	271 (40.1)	550 (40.2)
Diverse	3 (0.4)	6 (0.9)	9 (0.7)
Age			
18 - 24	28 (4.1)	23 (3.4)	51 (3.7)
25 - 34	95 (13.7)	108 (16)	203 (14.9)
35 - 44	123 (17.8)	121 (17.9)	244 (17.8)
45 - 54	114 (16.5)	135 (20)	249 (18.2)
55 - 64	188 (27.2)	172 (25.4)	360 (26.3)
65 - 74	95 (13.7)	86 (12.7)	181 (13.2)
75 - 84	41 (5.9)	29 (4.3)	70 (5.1)
>=85	7 (1)	2 (0.3)	9 (0.7)
Education			
Still in school	5 (0.7)	2 (0.3)	7 (0.5)
Primary education	29 (4.2)	26 (3.8)	55 (4)
Lower secondary education	113 (16.4)	112 (16.6)	225 (16.5)

Upper secondary education	544 (78.7)	536 (79.3)	1080 (79)
Living conditions			
Renter	212 (30.7)	254 (37.6)	466 (34.1)
Property owner	479 (69.3)	422 (62.4)	907 (65.9)
Job connected to airport			
Direct	17 (2.5)	13 (1.9)	30 (2.2)
Indirect	25 (3.6)	17 (2.5)	42 (3.1)
Not connected	649 (93.9)	646 (95.6)	1296 (94.7)
Airport in vicinity			
Cologne-Bonn Airport	418 (60.5)	401 (59.3)	819 (59.9)
Dortmund Airport	50 (7.2)	41 (6.1)	91 (6.7)
Dusseldorf Airport	222 (32.1)	232 (34.3)	454 (33.2)
Noise exposure			
High exposure (> 55 dB(A) L_{den})	430 (62.2)	410 (60.7)	840 (61.4)
Low exposure (≤ 55 dB(A) L_{den})	261 (37.8)	266 (39.3)	527 (38.6)
Participation			
Online	658 (95.2)	650 (96.2)	1308 (95.7)
Paper-pencil	33 (4.8)	26 (3.8)	59 (4.3)

Note. In brackets are the percentages.

7.4.2 Item Selection

The final 32 items on distributive fairness, procedural fairness, informational fairness and interpersonal fairness have high internal consistency as Cronbach's alpha (α) ranges from 0.89 to 0.92, as seen in Table 13. The final questionnaire, as well as instructions for assessment and the categorization of the items into the various facets, can be found in the Supplementary Materials , both in the original German language (Table A.20) and translated into English (Table A.21). Furthermore, a classification of items within the subfacets can be seen in Table A.22.

Table 13. Internal Consistency of the fAIR-In

Fairness facets	Number of items	Cronbach's Alpha (α)
Distributive Fairness	7	0.89
Procedural Fairness	13	0.90
Informational Fairness	7	0.89
Interpersonal Fairness	5	0.92
Total	32	0.96

7.4.3 Validity

Factorial Validity

As described in Chapter 7.3.3, four different models were computed in which fairness was described by four, three, two or one factor.

The results, seen in Table 14, show that the best-fitting model is Model 1, differentiating between four factors. The worst-fitting model is Model 4, the model with only one factor. To determine whether the Models also differ significantly from each other, the likelihood ratio (LR) test was used, which showed a significant result each time the Models were compared. This means that Model 3 is significantly better than Model 4, Model 2 is significantly superior to Model 3 and Model 1 is significantly better than Model 2. The results, seen in Table 14, are in line with the work of Colquitt (2001) and suggest that a conceptualization of fairness into four distinct facets is advisable and statically superior to other types of conceptualizations in the field of aircraft noise research.

Table 14. Model Fit of Different Fairness Structures

Model	Structure	χ^2 (robust)	Df	χ^2/df	CFI (robust)	RMSEA (robust)	RMSEA - CI	SRMS	AIC	LR-Test
1	4 Factor	1286.49***	458	2,809	.931	.055	.052 – .059	.046	52433.460	
2	3 Factor	1400.83***	461	3,039	.922	.059	.055 – .063	.047	52567.217	Model 1 vs. Model 2***
3	2 Factor	1664.08***	463	3,594	.899	.067	.063 – .070	.050	52881.206	Model 2 vs. Model 3***
4	1 Factor	2198.29***	464	4,738	.853	.081	.077 – .084	.058	53524.399	Model 3 vs. Model 4***

Note. CFI: comparative fit index; TLI: Tucker–Lewis index; RMSEA: root-mean-square error of approximation; LR test: likelihood ratio test. (***: $p \leq 0.001$).

Construct Validity

Table 15 shows all correlations between the different fairness facets and the other constructs, as described in Chapter 7.2.3. There is no statistically significant correlation between interpersonal trust and the fairness facets ($r = -0.02$ to $r = 0.06$). The correlation between

internal political efficacy and the fairness facets is small but significant for procedural fairness ($r = -0.10$) and for interpersonal fairness ($r = -0.09$). External political efficacy is more substantially and statistically significantly correlated with all fairness facets ($r = 0.20$ to $r = 0.29$). For the scales on injustice sensitivity, the results are mixed. There is a small significantly positive correlation between victim sensitivity and distributive fairness ($r = 0.18$), interpersonal fairness ($r = 0.14$) and procedural fairness ($r = 0.11$). We also find a small significantly negative correlation between procedural fairness and both observer sensitivity ($r = -0.11$) and perpetrator sensitivity ($r = -0.11$). Internal control perception correlates slightly but statistically significantly with procedural, informational and interpersonal fairness ($r = 0.10$ to $r = 0.12$).

Table 15. Correlation between Fairness Facets and Scales testing Construct Validity

Constructs	Distributive Fairness	Procedural Fairness	Informational Fairness	Interpersonal Fairness
Interpersonal Trust (KUSIV3)	-.02	.02	.05	.06
Political Efficacy (PEKS)				
Internal political efficacy	-.06	-.10**	.02	-.09*
External political efficacy	.20**	.25**	.29**	.29**
Injustice Sensitivity (USS-8)				
Victim sensitivity	.18**	.11**	.06	.14**
Observer sensitivity	-.05	-.11**	-.06	-.01
Beneficiary sensitivity	.02	-.02	-.05	-.01
Perpetrator sensitivity	-.09*	-.11**	-.07	-.06
Control Perception (IE-4)				
Internal control perception	.07	.10*	.12**	.12**
External control perception	.03	.02	-.03	-.02
Political Cynicism (KPZ)	-.10**	-.19**	-.23**	-.21**

Note. Pearson r correlation (**: $p \leq 0.01$, *: $p \leq 0.05$).

External control perception does not correlate with any of the fairness facets.

Political cynicism correlates slightly but statistically negatively with the fairness facets ($r = -0.23$ to $r = -0.10$). We also calculated the results separately according to noise exposure, whereupon it turned out that there are no systematic differences. An overview can be found in Table A.18.

Predictive Validity

Table 16 shows all correlations between the fairness facets and the criterion variables. As hypothesized, Table 16 shows that all fairness facets are negatively related to annoyance ($r = -0.53$ to $r = -0.68$), positively connected to acceptance of airport and air traffic ($r = 0.46$ to $r = 0.59$) and negatively correlated to willingness to protest ($r = -0.28$ to $r = -0.46$). All correlations are statistically significant.

Table 16. Correlation between Fairness Facets and Scales testing Predictive Validity

Construct	Distributive Fairness	Procedural Fairness	Informational Fairness	Interpersonal Fairness
Annoyance	-.68**	-.61**	-.53**	-.60**
Acceptance	.59**	.53**	.46**	.51**
Willingness to protest	-.46**	-.36**	-.28**	-.42**

Note. Pearson r correlation (**: $p \leq 0.01$).

7.5 Discussion

The present work had three central objectives. First, we outlined the process of item development. We generated items in different ways, including a search of the literature, expert interviews and focus groups. Then, we identified good items based on their measurement properties with statistical analyses using a large-scale online survey of airport residents.

Secondly, we examined the factorial validity of the questionnaire. A confirmatory factor analysis indicated that a classification into the four fairness facets of distributive, procedural, informational and interpersonal is superior to other categorizations of fairness in the context of aircraft noise research. This four-factor model achieved good model fit values and, thus, confirms the factorial validity of the questionnaire. As mentioned before, there has long been disagreement about the dimensionality of fairness questionnaires. In an organizational context, Colquitt (2001) was able to show that the four-factor structure is superior to other factor structures. In the context of aircraft noise, we can replicate these findings. A model describing fairness as four factors provides a significantly better fit to the data compared to alternative models also in the context of aircraft noise research.

The third aim of this study was to investigate the construct and predictive validity of the instrument. Regarding construct validation, it is worth noting that the correlations between fairness facets and the corresponding correlates were consistently small to moderate. This finding is actually favorable, as excessively high correlations would undermine the specificity

of the instrument. The results indicate that the fAIR-In measures constructs that are distinct from general interpersonal trust or injustice sensitivity, further confirming its construct validity. Our results suggest that the fAIR-In is an independent measurement instrument that does not assess stable personality traits, but instead captures specific aspects of the perception of airport management.

The very low correlations between interpersonal trust and the fairness facets indicate that the scales measure different things. Admittedly, we expected that people with a high score on this variable would also have higher perceived fairness aspects in relation to the airport. The low correlation could be explained by the fact that the fAIR-In does not measure general expectations, but instead specific circumstances.

Internal political efficacy (Beierlein et al., 2012a) correlates slightly with the fairness facets, but in particular, significantly negatively with procedural fairness. We had assumed a positive correlation on the assumption that people with high scores participate more actively in decision-making processes. The negative correlation could arise if these people, despite their willingness, notice that there are no or hardly any opportunities for participation.

External political efficacy (Beierlein et al., 2012a) correlates significantly positively with all fairness facets. We conclude that people who generally see possibilities to influence authorities and who report a stronger belief in authorities' intention to consider the concerns of the population are more prone to also perceive a higher fairness in the distribution of aircraft noise, the decision-making procedures coming to this distribution and the information and interaction connected with it.

As suspected, there is little to no correlation between injustice sensitivity and the fairness facets. Unexpectedly, however, there is a small but significant positive correlation between victim sensitivity and the fairness facets (Baumert et al., 2014). This means that residents that are more sensitive to injustice in regard to their own disadvantages judge the fairness of the aircraft noise distribution, the procedural aspects of airport management and interpersonal aspects higher. In general, it could be argued that people with increased sensitivity to injustice are more aware of topics related to injustice. Being more sensitive to injustice, these individuals may be more attentive of the airport's efforts and may have been in contact with the airport, resulting in a more positive image. As a result, individuals may be more likely to view fairness aspects of the airport as positive, while individuals with lower injustice sensitivity may have formed their opinions and lack the intrinsic drive to convince themselves otherwise.

With observer sensitivity, on the other hand, the opposite could be the case, namely that people who are not as affected themselves compare themselves with other residents who are

more affected by aircraft noise. This perceived difference could lead to the airport being perceived as less equitable.

A significant positive correlation was found between internal locus of control and the fairness facets for procedural, informational and interpersonal fairness. As assumed, this could be due to the fact that people with high values do not consider themselves helpless and actively seek opportunities for participation.

External locus of control correlates only very slightly and not significantly with the fairness facets of the fAIR-In. Since this perception is not supposed to be captured by the fAIR-In, this result can be interpreted as an indication of divergent validity. Thus, a high correlation would indicate that the fAIR-In does not describe people's perception of the airport in the region, but rather the tendency to have no decision-making power anyway, regardless of circumstances.

Unlike external political efficacy, political cynicism does not refer to the entire political institution, but describes the skepticism and distrust of the current political authorities. With a negative correlation varying between $r = -0.10$ and $r = -0.23$, it can be assumed that this negative correlation is also evident. We conclude from these results that people who generally question trustworthiness of (current) political authorities are also more likely to mistrust airport authorities. Thus, indications exist that the fAIR-In really does measure aspects related to (mis-)trust in authorities.

However, in sum, all of the considered scales comprise rather divergent constructs instead of convergent constructs. Attempts should be made in future research to identify contracts that can serve as scales for convergent validation in order to further test the construct validity of the newly developed fAIR-In.

In regard to predictive validity, all hypotheses were confirmed. The correlations found between all fairness facets and the predicted variables of annoyance, acceptance and willingness to protest are very high, suggesting that all four facets are relevant predictors.

Perceived airport fairness is negatively related to annoyance and positively related to (a) the acceptance of the airport and air traffic and (b) the willingness to protest. These are exactly the relationships that were predicted and show that the fAIR-In is able to measure practically relevant aspects of airport management, making it a useful evaluation tool. The relationships between fairness and other factors found here can be embedded in the context of research on non-acoustic factors, in particular the model proposed by Stallen (1999) that considers annoyance as a stress response to noise. From the perspective of this theoretical

model, the perception of fair procedures, information and behavior of airport authorities can serve as a source for control and the capacity to cope with the noise.

The comparatively low correlations between fairness perceptions and the willingness to protest may also be explainable. Whether or not a person shows protest behavior depends on various factors including personality, situational and cultural aspects—even when the perceived unfairness is high. Similarly, as pointed out before (e.g. Maziul, Job, & Vogt, 2005), the number of complaints about aircraft noise does not reflect the degree of noise annoyance around airports to the full extent. According to the authors, complaining behavior results from an interaction between many personal and environmental factors and not only annoyance due to noise. The fact that protest behavior is the result of a variety of different influencing factors explains why fairness is not as strongly associated in comparison to annoyance and the acceptance of the airport and air travel. In subsequent work, a multiple regression analysis or a structural equation model should be carried out to further consider the respective correlations and intercorrelations and to further elaborate the specific influences of the respective fairness facets.

The results found with regard to the strong relationship between fairness and other aircraft-noise-induced responses such as annoyance, acceptance and willingness to protest can only be embedded in current research to a limited extent, as little empirical research is available at this point in time. However, the present results support the findings from a laboratory study approach by Maris (2008) suggesting that providing fair procedures by giving voice and process control to the noise-affected individual reduces noise-induced annoyance whilst unfair procedures (i.e., ignoring stated preferences) increase annoyance. While Maris (2008) examined the effect of procedural fairness on annoyance, the present study goes beyond, as it also shows a strong association among distributive, interpersonal and informational fairness and annoyance. To this end, the present findings confirm the assumptions of Stallen's theoretical framework (1999) according to which a fair exchange between the airport and its residents that includes giving information and justification helps affected residents cope with the noise. A central point in this theoretical framework is the assumption that providing relevant information enhances the foreseeability of noise and, thus, increases residents' perceived control over the noise situation.

Especially in times of (operational) changes at the airport, which are connected with changing noise levels, decisions at the airport and their justification play a major role in the acceptance of outcomes.

The present findings suggest that aspects of distributive, procedural, informational, and interpersonal fairness are of great relevance to how residents react to these processes and final

decisions and how annoyed residents eventually are. In addition to annoyance, the present work also provides evidence that fairness has an influence on the acceptance of the airport and air traffic, as well as the willingness of residents to protest.

The correlations found point at new scopes for further analysis of inter-relationships. Since the development of the fAIR-In was the main focus of this paper, it was not possible to go further into these associations and possible moderation and mediation effects. In a future publication, these relationships will be analyzed and discussed within the framework of a comprehensive structural equation model.

In the future, these relationships could be analyzed in depth and, thus, expand the current understanding of non-acoustic factors in connection with fairness facets in the context of aircraft noise management.

7.6 Limitations

One major limitation that needs to be mentioned was that, due to the COVID-19 pandemic, air traffic has decreased considerably since the beginning of 2020; however, this was not included in the survey questions. For example, the ICBEN question on noise annoyance asked how disturbed or bothered people felt in the last 12 months. Since the survey was conducted at the end of 2021, the actual extent of noise annoyance and, thus, also potentially the fairness-related perception might not have been correctly represented. During the study and through telephone contact with survey participants, comments were made that air traffic was reduced so much during the COVID-19 pandemic that there was currently hardly any annoyance due to aircraft. The participants pointed out that this was due to the current situation and that they also expected that once air traffic increased again, the nuisance would also increase again. For this reason, the measurement of annoyance and related aspects such as perceived fairness may be somewhat biased. However, as the majority of respondents stated that they live in their own home, it can be assumed that aspects of attitudes towards the airport have existed for some time and are therefore unlikely to change as a result of the reduction in flights. However, the circumstances of the survey within the COVID-19 pandemic warrant further investigations and replications of the study results in future surveys. Furthermore, future studies should capture the duration of residence, as this can influence attitudes towards the airport and the perceptions of fairness aspects. Unfortunately, this was not included in the present study.

Due to the focus of the manuscript on the development and validation of the fAIR-In, noise exposure was not included in the standard calculations. However, it can be seen (see Table A.18 and Table A.19) that there are no significant differences between the higher- and lower-

exposure groups of residents in terms of the results. These results also emphasize yet again the relevance of the fAIR-In. This shows that fairness does not only play a role for highly exposed people, but that fairness also has a significant influence on annoyance, acceptance of the airport and air traffic, and the willingness to protest at comparatively low levels of aircraft noise exposure. Furthermore, in this study, the method of sending out flyers according to postal codes that were matched with noise contour maps did not allow for a higher resolution of the exact noise exposure. In future studies, a more precise differentiation between different noise categories could be achieved by targeting the respondents who are located in specific areas, specifically areas with noise levels over 65 dB(A) L_{den} . Another limitation of the study concerns the selection of participants. Although the flyers were distributed to all households in the selected areas, participation was not random but rather self-selected. Thus, it cannot be ruled out that a self-selection bias came into play in the sample. For example, people who describe themselves as highly annoyed are associated with a higher level of suffering and, thus, also a desire to change something about the current situation. It can therefore be assumed that the level of aircraft noise annoyance in this sample is higher compared to the general population in the region. Nevertheless, the results of the present work are to be considered important, as they allow the foundation for further research on fairness aspects in the context of aircraft noise.

As this study is a cross-sectional study, no causality can be concluded. It is therefore not clear whether people who feel that they are treated more fairly by the airport are less annoyed, or whether people who feel less annoyed perceive the airport to act more fairly. Drawing on the work of Maris et al. (2007b), who found a causal relationship between fairness and annoyance, it could be argued that the direction of the relationship is from fairness to annoyance. However, obtaining further longitudinal data on fairness perceptions on the one hand and noise responses such as annoyance, acceptance of airport and air traffic as well as willingness to protest on the other is highly recommended in future noise surveys and epidemiological examinations.

7.7 Practical Implementation of the fAIR-In in Airport Regions

The present paper introduces the fAIR-In, an empirically validated psychometric instrument that may drive future research in the field of aircraft noise. Furthermore, the aim was to provide a tool to assess the relationship between an airport and its residents and therefore serve as a foundation for subsequent measures to address any existing concern and improve the relationship, that is, lead to a fairer and more trustful relationship between airport operators and residents in the long term.

With regard to the implementation of interventions in the context of airport management, the fAIR-In is in a unique position to provide essential support.

For example, the implementation of the fAIR-In around the airport can provide evidence as to which aspects of fairness are perceived particularly well or especially negatively. This enables targeted and efficient interventions to be planned with the aim of increasing the perceived fairness and building a neighborly relationship with the airport. Furthermore, it is also possible to evaluate implemented interventions in the sense of a pre-post comparison. Most of the airport's interventions are implemented and expected to have the desired effect. However, it turns out that hardly any evaluation of the activities is carried out (Heyes et al., 2022). Nevertheless, this does not allow any conclusions to be drawn about whether the intervention was useful and truly effective. Additionally, it is not possible to make comparisons between different airports and to empirically determine the benefits of the measures implemented. The fAIR-In offers a low-cost, quick-to-implement tool to help airports close this important gap.

Since the primary issue with aircraft noise is that it is man-made noise, unlike natural sound sources, aspects play a role here that can also be applied to other scenarios. Noise sources that will become increasingly relevant in the future, such as noise from wind turbines, heat pumps, or even drones or air taxi noise, can cause annoyance among residents. Therefore, an early integration of fairness in planning procedures is relevant to minimize the negative consequences of noise for residents.

7.8 Conclusions

This study establishes the effectiveness of the fAIR-In as a psychometric instrument for evaluating fairness-related dimensions in airport and noise management. Results on the validity of the inventory suggest that the four fairness facets that were derived in an organizational and juridical research context (distributive, procedural, informational and interpersonal fairness) can be replicated in the context of aircraft noise exposure and its management by the airport. These four fairness facets can be obtained with a high reliability in terms of internal consistency. The fAIR-In is capable of measuring aspects that characterize more or less fair distributions, procedures and interactions instead of mere personality traits. Furthermore, the fAIR-In demonstrates strong predictive power regarding important consequences of unwanted exposure to aircraft noise including noise annoyance, airport acceptance and willingness to engage in protest. As a result, airport managers can rely on the fAIR-In as a reliable, valid and practical tool. By utilizing the fAIR-In, airport managers can implement targeted interventions, monitor

progress and evaluate outcomes, thus facilitating the development of long-term improvements in the relationship between airports and neighboring residents.

8. Synopsis: Contribution of the Thesis

The three research articles in this dissertation attempt to answer the research questions that have emerged from the gaps in previous existing literature (Chapter 3). The following chapter describes the theoretical, methodological and empirical contribution of this thesis in the context of aircraft noise research.

8.1 Theoretical Contributions

As elucidated in the introduction, the annoyance caused by aircraft noise is not solely attributable to the noise itself (Guski, 1999). Non-acoustic factors, like the predictability of noise events or the attitude towards the noise source can significantly influence the emergence and intensity of noise annoyance (Bartels et al., 2022; Guski, 1999; Schreckenberget al., 2017a). The rationale behind this is that, unlike natural sounds, aircraft noise is a product of human activity and can, thus, be characterized as a social conflict (Maris, 2008; van Gunsteren, 1999), with the noise being a persistent reminder of unfair treatment. The occurrence of aircraft noise results from decisions made by individuals or institutions, making it a conflict of fairness. However, the exploration of aircraft noise annoyance from the vantage point of social psychology remained relatively uncharted territory in prior research.

The work conducted by Maris (2008) has highlighted the pivotal role of fairness in the development and intensity of annoyance. However, this study predominantly focused on procedural fairness. As of now, there has been a noticeable absence of a comprehensive theoretical framework for fairness within the context of aircraft noise research. Such a perspective would broaden the understanding of noise reactions by recognizing the fairness conflict as an underlying factor behind many of the non-acoustic factors identified in research. A theoretical framework in which fairness plays a central role would also provide starting points for empirically based communicative interventions in order to enhance the residents' perceived fairness and, thus, results in managing the acceptance of the airport, noise annoyance and potentially even protest behavior.

This thesis addressed this gap, by providing a theoretical framework for fairness in the context of aircraft noise research, defining the distribution of aircraft noise as a fairness dilemma. The dilemma results from the fact that the aircraft noise must be distributed among the residents resulting in some residents inevitably experiencing more noise than others. This leads to some residents having to bear the negative consequences of the noise (such as adverse

health effects, loss of property value), while the benefits associated with the airport, such as convenient access to travel or potential job opportunities, are accessible to all residents. Building upon prior research on fairness, particularly within the domains of organizational and judicial psychology, a categorization was introduced, encompassing distributive, procedural, informational, and interpersonal fairness, as detailed in Colquitt et al. (2001). This framework was adapted to the unique context of aircraft noise. While the fundamental challenge of addressing the inherently unfair distribution of noise remains a problem, research within this field does present opportunities to enhance the fairness of aircraft noise management. Consequently, it offers a means to at least manage the emotional and attitudinal repercussions resulting from long-term noise exposure (RQ1 & 2).

Research on *distributive fairness* applied to the context of aircraft noise research helped to gain an understanding of which distribution of aircraft noise might be considered to be fairer. In line with the *equity* rule (Adams, 1965), noise should be distributed in such a way that the ratio of perceived disadvantages caused by aircraft noise and perceived benefits due to the airport is balanced for all residents. *Equity* is therefore perceived when the cost-benefit ratios between individuals are seen to be equivalent (Adams, 1965). Similarly, a distribution aligned with the *equality* rule (Leventhal, 1980) could be envisioned, wherein noise is distributed uniformly among all residents, irrespective of other noise sources and factors. The *needs* rule (Leventhal, 1980) would advocate for a distribution providing special protection from aircraft noise for vulnerable individuals such as children, sick or elderly people. Although no clear answer can be given as to which distribution of noise would be most likely to improve the perception of fairness, even with regard to previous research in the area of aircraft noise, it provided grounds for improving the *equity*, by enhancing the perceived benefits from the airport in order to make the cost-benefit ratio as balanced as possible. In order to address the individual costs (i.e. noise), this thesis reviewed research on noise insulation, noise-free times (respite) and compensatory payments for the reduction of real estate value. To increase individual benefits, possibilities such as a share of the profits, reduced parking costs at the airport or discounted ticket prices for residents affected by aircraft noise were discussed.

Drawing from research on *procedural fairness* (Bobocel & Gosse, 2015; Folger, 1987; Leventhal, 1980; Thibaut & Walker, 1975), a variety of further recommendations have been made on how airport management can be improved to establish a sense of fairness. In addition to granting *process* and *decision control* to residents, the *representativeness rule* (Leventhal, 1980) states that concerns and opinions of all affected parties should be represented when making decisions. The *consistency rule* (Leventhal, 1980) states that processes at the airport,

e.g. regarding noise protection measures, should be applied consistently to all affected residents. The *bias suppression rule* (Leventhal, 1980) advocates for decisions at the airport not be made purely on the basis of self-interest, but rather for the airport adopting a neutral and impartial perspective. With regard to the *accuracy rule* (Leventhal, 1980), decisions should be based on accurate and relevant information, and if incorrect decisions are made, there must be ways for residents to challenge these decisions. Finally, all decision-making processes should adhere to fundamental ethical and moral standards (Leventhal, 1980). Interventions in the proximity of airports were reviewed in terms of their integration of procedural fairness aspects and the impact of such efforts. As an example of the establishment of a genuine two-way exchange, Vienna airport was mentioned, which has set up a dialogue forum to give voice to affected individuals.

Research on *informational fairness* (Bies, 1986; Greenberg, 1993) indicates that it is essential that the airport further provides transparent information, communicating truthfully with residents and offering detailed justification for decisions. In general, the research on *interpersonal fairness* (Bies, 1986; Bies, 2001) underscores that respectful interaction with residents further strengthens the perception of fair treatment by the airport. In the context of aircraft noise research, it has been shown that aspects of informational fairness have been a recurring theme, for example in Porter's working group (2017), which emphasized that good communication and transparent and respectful engagement are key aspects in implementing interventions successfully.

By framing the distribution of aircraft noise as a fairness conflict, this dissertation made a significant contribution by introducing a valuable theoretical perspective to understanding the origin and potential alleviation of noise-related annoyance. The underlying aspect, which might mediate the annoyance response due to noise, can be seen as *a lack of fairness* (RQ1). By conceptualizing fairness of aircraft noise management through the lens of *distributive, procedural, informational* and *interpersonal* fairness, this dissertation provided a holistic understanding on the negative reactions observed among residents impacted by aircraft noise. Additionally, many of the non-acoustic factors commonly addressed in literature, such as attitudes toward the noise source and the predictability of future noise events, can be more effectively understood and interconnected using the theoretical framework introduced in this dissertation. These factors can be recognized as manifestations of a deficiency in fairness. Furthermore, this dissertation also provided a conceptual foundation for further efforts aimed at improving the relationship between residents and the airport. Hence, guided by the insights from this thesis, future interventions focused on improving perceived fairness can be firmly

grounded in theory, potentially increasing their efficacy and subsequently enhancing the quality of life of residents affected by aircraft noise (RQ2). Table 3 provides a concise summary of all facets and subfacets of fairness according to their application and feasibility in the context of aircraft noise research.

8.2 Methodological Contributions

The conceptualization of aircraft noise as a fairness dilemma, along with the comprehensive review of research dealing with fairness in the context of aircraft noise, has helped to identify relevant methodological weaknesses in this field. An evident constraint was the absence of a validated and reliable measurement instrument, capable of gauging the multidimensional nature of fairness within aircraft noise research. “Without measurement, such theorizing remains just that: theoretical” (Colquitt & Rodell, 2015, p. 187). As Colquitt and Rodell (2015) stated in their review of instruments measuring fairness, the ability to quantify something reflects the knowledge one has about an area. Although Bartels (2014) initiated addressing this gap, the study was confined by a small sample size. Consequently, a primary objective was to bridge this gap by employing a larger sample and developing and validating a comprehensive questionnaire encompassing the broad spectrum of fairness aspects within the context of aircraft noise research, while withstanding psychometric requirements (RQ5).

Chapter 7.2.2 provided an initial outline of the process undertaken to develop items intended for measuring fairness facets pertinent to airport management, from the perspective of residents exposed to aircraft noise. The items have been developed from three different sources, thereby offering a holistic perspective. First, based on the insights gained from Research Article 1 (Chapter 5), the categorization into the four fairness facets distributive, procedural, informational and interpersonal fairness was defined. Additionally, established questionnaire items were utilized (Colquitt, 2001; Colquitt & Rodell, 2015), differentiating further between subfacets (e.g., representativeness of procedural fairness) as a basis for the questionnaire. Furthermore, on the basis of the analyses for Research Article 2 (Chapter 6), the statements of residents affected by aircraft noise were explored in order to identify further relevant aspects regarding the development of items. Thirdly, experts in aircraft noise research and airport authorities were surveyed via the critical incident technique, shedding light on experiences in dealing with disgruntled residents. These real-life situations and resident accusations were pivotal in shaping further items and offered insight into typical fairness-related scenarios. With the help of these three methods, a total of 68 items were formulated, which were assigned to the fairness facets with their associated subfacets (see examples in Table 8). In order to further

test and validate the developed questionnaire, a large online survey was conducted, which involved sending out almost 100,000 flyers to recruit test subjects. This resulted in a comprehensive dataset of 1,367 responses. The final selection of items was based on the analysis of the internal consistency of the respective facets, with the aim of maximizing it. Furthermore, care was taken to exclude redundant items and items that do not load highly on the respective facets, according to Colquitt and Rodell (2015) and Tabachnick et al. (2007). These calculations resulted in a reduced final item number of 32. With an internal consistency of Cronbach's Alpha, $\alpha = 0.89$ to 0.92 , depending on the subfacets, a very high internal consistency was achieved. Finally, the questionnaire also proved to be well suited in the sense of construct validation, as the correlations found with other, thematically similar scales such as interpersonal trust, political efficacy, sensitivity to injustice, perception of control and political cynicism were low to moderate. This was desired, as the aim was to measure a distinct and novel construct, independent of existing scales. Excessive correlation with these mentioned scales would suggest a lack of specificity in the instrument. The outcomes affirm that the Aircraft Noise-Related Fairness Inventory (fAIR-In) assesses an independent construct, devoid of associations with stable personality traits.

The creation of the fAIR-In bears significant practical implications for the realm of noise research and has the potential to substantially advance studies in this field. Currently, the proportion of unexplained variance in aircraft noise annoyance is still high (Bartels et al., 2022). The developed fAIR-In can contribute to an improved explanation of variance by integrating fairness within airport management, thereby enhancing comprehension of annoyance reactions among residents. Furthermore, the fAIR-In holds promise as a practical tool, by helping airport managers to build a more neighborly relationship between the airport and residents and, thus, improving the quality of life of residents.

For instance, by deploying the fAIR-In in the vicinity of an airport, valuable insights can be gathered regarding the aspects of fairness that are perceived positively or negatively. This information can then be leveraged to strategize focused and efficient interventions aimed at enhancing perceived fairness and fostering a harmonious relationship with the local community and the airport. Moreover, the fAIR-In facilitates the assessment of these interventions through a before-and-after analysis. While most of the airport's interventions are put into action with anticipated positive outcomes, it is evident that a limited amount of assessment is conducted on these endeavors (Heyes et al., 2022). Consequently, it remains uncertain whether these interventions are truly effective and beneficial in terms of enhancing fairness or reducing annoyance. Furthermore, the ability to compare interventions across

various airports and empirically quantify the advantages of the implemented measures is compromised. To address this critical gap, the fAIR-In emerges as an economical and expedient solution, aiding aircraft noise management in bridging this crucial shortfall in the future.

8.3 Empirical Contributions

The empirical contributions of this dissertation are diverse, but can be condensed into three central aspects.

The theoretical application of fairness research to the context of the aircraft noise debate as mentioned earlier was reinforced by additional empirical, qualitative research via focus group discussions and in-depth interviews. The statements of residents living in the vicinity of Cologne-Bonn Airport, Düsseldorf Airport and Paris-Charles-de-Gaulle Airport were assigned to the four fairness facets aforementioned, allowing a deeper understanding of the relevance of these fairness aspects (RQ3). Residents stressed that they want to receive a fair compensation for the cost they incur from living near the airport, such as sleep disturbance. Furthermore, they highlighted the necessity for meaningful involvement in airport decision-making, and access to honest and transparent information. Although it was not possible to classify statements made by those affected under certain subfacets, such as equality of distributive fairness or ethicality of procedural fairness, the relevance of fairness aspects from the point of view of those affected was once again emphasized in this qualitative study (RQ4). It has been shown that mutual understanding and fair interaction between the airport and residents could help to decrease the negative attitude and the annoyance due to the noise and to establish a more positive relationship in the long term.

As a second empirical contribution of this thesis, it is worth mentioning that the dimensionality of fairness was analyzed in the context of aircraft noise research. The division into the four fairness facets distributive, procedural, informational and interpersonal fairness is already established in the field of fairness research in the organizational context (Colquitt, 2001), but needed to be examined in the context of aircraft noise research. In Chapter 7.3.3, a confirmatory factor analysis was conducted to compare different models describing fairness as either one overarching factor, two factors, three factors or four factors. These different categorizations were also discussed in the history of organizational fairness research (Bies & Moag, 1986; Greenberg, 1990; Niehoff & Moorman, 1993). It was shown that, as in the context of organizational psychology, the division into the four fairness facets also performs best in the present context, providing empirical evidence for its factorial validity (RQ6).

Another important empirical contribution was the analysis of the relationship between fairness and other important variables in the context of aircraft noise research, namely the annoyance due to the noise, the acceptance of the airport and air traffic and the willingness to engage in protest (RQ7). The results are an important and new finding, as this has hardly been studied in research on aircraft noise annoyance. The results support the findings of Maris (2008), which showed that fair procedures can reduce noise-induced annoyance by giving voice and process control, whereas unfair procedures increase annoyance by ignoring the stated preference. However, the results of this dissertation went beyond this by demonstrating that all four fairness facets, namely distributive, procedural, informational and interpersonal fairness, significantly contribute to highly relevant aspects in the context of aircraft noise debate. All four fairness facets were found to be negatively related to annoyance by aircraft noise and willingness to engage in protest, and positively related to acceptance of the airport and air traffic (see Table 16). The results shown here, confirm the assumption of Stallen's theoretical framework (1999), according to which a fair exchange between the airport and the residents helps them to cope better with noise. In this theoretical model, a central assumption is that providing transparent information increases the predictability of noise and consequently increases residents' perceived control over the noise situation. Annoyance, conceptually defined as a stress response, can therefore be reduced due to the increased perceived level of psychological control. In summary, the findings presented indicate that fairness constitutes a fundamental and pivotal element within the realm of aircraft noise research.

8.4 Conclusion and Limitations

The primary objective of this dissertation was to delve into the concept of fairness in the context of aircraft noise research. The fundamental hypothesis was that fairness, as a construct, holds significant relevance in aircraft noise research. However, there was a notable dearth of systematic and in-depth research on this particular aspect. The three research articles that comprise this thesis, focused on fairness within the context of aircraft noise research and offered a comprehensive and holistic examination.

A psychological perspective was adopted, rooted in social justice research, redefining the matter of aircraft noise annoyance as a result of a conflict of fairness. To achieve this, insights from other domains were applied to aircraft noise research, supplemented by qualitative data from residents affected by aircraft noise. Furthermore, a quantitative study facilitated the creation of a questionnaire designed to reliably and validly measure fairness – a pivotal component of further research in the context of aircraft noise research.

The research articles forming the foundation of this dissertation significantly contribute to comprehending reactions to long-term aircraft noise and lay the groundwork for future initiatives aimed at mitigating noise impact on citizens, thus, enhancing the quality of life for residents affected by aircraft noise.

Initially, a theoretical framework was developed (Chapter 5) to explore the concept of fairness within the realm of aircraft noise research, drawing upon insights from various fields, primarily organizational and judicial psychology (for an overview, see Colquitt et al., 2001). This framework conceptualized noise annoyance as a fairness dilemma, detailing its facets: distributive, procedural, informational, and interpersonal fairness. This conceptualization helped to review existing literature and previous effects in the field of aircraft noise management assigning them to the four facets of fairness and exploring ways to foster a fair perception of the airport among residents resulting in potential positive impact on residents' quality of life. Within this theoretical framework, it has been demonstrated that all four dimensions of fairness—namely, distributive, procedural, informational, and interpersonal fairness—have relevance and apply to the aircraft noise context. Furthermore, numerous examples and studies have been identified and associated with each of these fairness facets, highlighting its relevance. Additionally, it has been found that a variety of non-acoustic factors acknowledged in aircraft noise research can indeed be linked to issues of fairness. For instance, the perceived control and predictability of future aircraft noise events can be viewed as a matter of informational fairness. This work highlighted the relevance of fairness in the context of aircraft noise management and suggested that there is great potential for the systematic integration of fairness aspects to increase the effectiveness of interventions aimed at improving the relationship between affected residents and the airport.

The second research article (Chapter 6), qualitatively analyzed fairness from the view of noise affected residents. Residents from various European regions living around airports were engaged in focus group discussions and in-depth interviews, exploring their perceptions and ideas of a fair and neighborly relationship with the airport. The results of the qualitative content analysis demonstrated that, from the residents' point of view, fairness is an essential component for establishing a neighborly relationship with the airport. All dimensions of fairness seem relevant from the perspective of those affected and statements could be assigned to the four fairness dimensions. Furthermore, this qualitative work was able to show that certain fairness facets are more relevant and present than others. Apart from noise reduction at source, which can be categorized as reducing the cost in the context of distributive fairness, two other crucial dimensions stood out: informational fairness and procedural fairness. Residents expressed

significant concerns regarding these fairness aspects, with a lack of trust in the airport's communication efforts, as they feel information is not conveyed truthfully and transparently. Furthermore, residents affected by aircraft noise pointed out that they wish for proactive behavior from the airport in addressing their concerns, emphasizing the importance of procedural fairness.

The second research article provided valuable insights into the views and experiences from noise affected residents, which highlighted fairness to be an important aspect in this context. Further, these findings underscored the necessity of incorporating fairness aspects in order to establish a neighborly relationship between the residents and the airport

The third research project aimed to build upon insights gained from previous research and focused on the development and validation of a multidimensional psychometric questionnaire. This questionnaire was designed to effectively measure different dimensions of fairness in airport management from the perspective of residents who are affected by aircraft noise. The study's results demonstrated that this multidimensional approach to fairness, breaking it down into these four specific facets, was not only theoretically sound but also empirically robust when compared to other classification methods, underscoring the significance of considering distributive, procedural, informational, and interpersonal fairness when introducing fair airport management.

Furthermore, the research project aimed to investigate whether fairness had a significant relationship with important outcomes in the context of aircraft noise. The study assessed various outcomes, including noise annoyance, acceptance of the airport and air traffic, and willingness to engage in protest. The findings of the study confirmed these assumptions, revealing that all four facets of fairness (distributive, procedural, informational, and interpersonal) were negatively correlated with noise annoyance and protest behavior and positively correlated with the acceptance of the airport and air traffic. In other words, when residents perceived fairness in airport management, they were less likely to be annoyed by noise and less inclined to participate in protests against the airport, while showing more acceptance of airport activities.

Overall, the results highlighted the crucial role of fairness in shaping residents' perceptions of the airport and their reactions to aircraft noise over the long term. The study's approach provided a comprehensive framework for understanding fairness in airport management and its impact on noise affected communities. It underscored the importance of addressing fairness as a key factor in mitigating negative reactions to aircraft noise and improving overall community relations with airports.

In sum, the concept of fairness as a multidimensional aspect in the context of aircraft noise research was introduced. As prior research has suggested, aircraft noise annoyance is not solely attributed to noise itself. It was shown that non-acoustic factors, such as attitudes toward the noise source, expectations, and fears, play a substantial role, intensifying perceived annoyance and, in some instances, leading to protests against the airport. From the results, we infer that aspects that were previously treated in isolation, such as attitudes toward the airport, stem from a lack of airport management practices aligned with fairness prerequisites. Consequently, this dissertation serves as an authoritative guide for establishing criteria that foster neighborly relations between residents and airports, potentially facilitating a more neighborly relationship between residents and the airport, eventually resulting in a higher quality of life.

While the limitations of individual research articles are discussed within their respective chapters, general limitations and points of criticism applicable to the thesis warrant acknowledgment here.

A central limitation that extends throughout this thesis arises from the non-random selection of subjects. For the second and third research project, flyers were distributed or advertisements were made to recruit participants. Consequently, only individuals who actively participated were included in the study, introducing a potential self-selection bias. This bias might overrepresent individuals experiencing greater suffering, potentially skewing study results. For instance, individuals who experience heightened levels of noise annoyance may have been more inclined to participate due to their stronger desire to initiate change in their current situation, viewing participation in the study as a means to accomplish that goal.

Future studies focusing on residents' fairness perceptions should implement randomized selection procedures to mitigate this risk, for example ensuring a representative sample by sending out personalized letters on the basis of available population registers. Furthermore, the generalizability of results presented might be constrained by the fact that the sample studied, might not reflect the population of all people living near airports.

Another limitation pertains to the lack of differentiation between high-rate and low-rate change airports. High-rate airports are seen as airports that are undergoing changes or changes that are announced, such as the opening of a new runway and a resulting future increase in flight numbers. Low-rate change airports are relatively stable, where no major changes are planned in the foreseeable future (Guski et al., 2017). Furthermore, the effect sizes of paths between non-acoustical factors and annoyance are different in high-rate change vs. low-rate change situations in airport regions (Schreckenberg et al., 2017a; Schreckenberg et al., 2017b), indicating a dynamic process in the relationship between non-acoustic factors and annoyance.

Mechanisms driving this phenomenon are yet to be fully understood. However, these circumstances pose distinct challenges for residents that warrant further assessment. Future research should consider this distinction when evaluating airports and explore potential connections between these changes and fairness aspects. For instance, insufficient information or citizen participation could induce fear in the population, negatively impacting attitudes toward the airport and intensifying annoyance.

Last but not least, the causal relationship between fairness and annoyance has still not been conclusively clarified. Although the results of Maris et al. (2007b) seem to speak for a causal relationship from fairness to annoyance, the reverse relationship cannot be completely excluded at this point in time.

9. Directions of Future Research on Fairness in the Context of Aircraft Noise Research

This dissertation contributes to noise research theoretically, methodologically and empirically. Furthermore, the findings of this dissertation enable further research in this field and can help improving the quality of life of residents around airports. Based on the results presented here, three central aspects can be derived which can be addressed in future research projects (RP).

Fairness in the context of aircraft noise research: a structural equation model (RP1). Fairness is a multidimensional and complex concept, about whose effects in the context of aircraft noise research not much is currently known. In this thesis, the first empirical evidence was obtained that there is a relationship between the individual fairness facets and annoyance caused by aircraft noise, the acceptance of the airport and air traffic and the willingness to protest. However, this empirical evidence currently only amounts to correlations, resulted from a cross-section study approach. In order to gain a deeper understanding of the various interactions and causalities, further calculations in the sense of a structural equation model (SEM) would be of great interest, which are based on longitudinal data, allowing for testing causalities. Here, the complex interrelationships and interdependencies could be illustrated.

It is currently assumed that there is a causal relationship between fairness and the relevant outcome variables like annoyance (see Maris et al., 2007a). Further interrelationships of other facets of fairness such as distributive, informational and interpersonal fairness on annoyance and in addition on the acceptance of the airport and air traffic have not been investigated further at present.

Such a research project would help to deepen the understanding of the interrelationships between fairness and relevant predictor variables. These insights could help to improve targeted interventions to improve the quality of life of residents living close to the airport. Studying causal relationships with a longitudinal study would have the potential to be a valuable basis for future research, but also for political decision-making on the reduction of aircraft noise annoyance, resulting in a higher quality of life of airport residents.

Evaluation of the effectiveness of the fAIR-In. A guided intervention at the airport with the aim of improving neighborliness between residents and the airport (RP2). Many interventions at the airport are often not designed on a scientific basis or are scarcely evaluated (Heyes et al., 2022). With the help of the fAIR-In, which is presented in Chapter 7, a research project could be designed to address this issue.

A research project could be implemented at an airport to demonstrate the benefits of the newly developed fairness questionnaire and to investigate its effectiveness in comparison to conventional interventions. To begin, a survey of residents residing near the airport could be conducted to gauge their current perceptions of the airport in relation to fairness-related perceptions. Additionally, the existing level of aircraft noise annoyance, as well as attitudes toward the airport and inclinations for protest, could be assessed. Based on these insights, a precisely targeted intervention project could be devised. For instance, the survey might reveal a deficiency in the perception of informational fairness (regarding truthfulness and justification). In response, a focused intervention could be devised, concentrating specifically on enhancing truthfulness and justification. For example, citizen dialogues can be organized in which the airport answers all the residents' questions honestly and adequately clarifies the decisions made at the airport. An information leaflet could also be prepared and distributed among all airport residents. A key precondition for this intervention would be that the concerns and queries of residents are addressed with utmost honesty and transparency.

Following such an intervention, the fAIR-In could again prove valuable as an assessment tool to measure the effectiveness of the initiative. This evaluation might demonstrate an improvement in the perception of aspects related to informational fairness, along with an overall enhancement in attitudes and acceptance of the airport. Additionally, a reduction in perceived aircraft noise annoyance would further substantiate the success of these interventions.

Effects of Fairness on Physiological Stress Parameters (RP3). In this thesis, the focus was situated around effects of fairness on noise-related aspects such as annoyance, acceptance of airports and air traffic, and on the willingness to engage in protest behavior. Drawing inspiration from the notion that annoyance can be seen as stress response (Babisch, 2002; Stallen, 1999), and acknowledging its association with various adverse health outcomes related to noise annoyance (Basner & McGuire, 2018; Clark & Paunovic, 2018a; Guski et al., 2017; Nieuwenhuijsen et al., 2017; Śliwińska-Kowalska & Zaborowski, 2017; van Kempen et al., 2018), it would be of great interest to delve deeper into this connection. The aim of such a research project would be to investigate the effects of fairness to potentially alleviate physiologically measured stress level, as seen in prior research in other contexts (Vermunt & Steensma, 2003)

By conducting a laboratory experiment, it would be feasible to systematically expose individuals to fair and unfair conditions. Continuing from the work of Maris et al. (2007b), who examined the effect of procedural fairness on perceived annoyance due to aircraft noise in the laboratory, this research project could go one step further. By methodically manipulating fair

and unfair circumstances—including distributive, informational, and interpersonal fairness—it becomes possible to ascertain their influence on stress markers that are established through physiological measurements. Parameters such as pulse amplitude, heart rate variability, blood pressure, and cortisol levels hold potential as reliable indicators of physiological stress (e.g. Reisman, 1997). Such an experimental undertaking could significantly contribute to the enrichment of our understanding regarding the intricate interplay between fairness, stress, and the emergence of aircraft noise annoyance. By understanding the mechanisms between the multidimensional aspect of fairness, annoyance due to noise and subsequently the impact on physiologically quantifiable stress parameters, a more holistic comprehension of these complex dynamics could be achieved.

Appendix

A. Supplementary Materials

Table A.17. Sample Description According to the Airport in the Vicinity

	CGN	DUS	DTM
	N (%)	N (%)	N (%)
Total	819 (59.9)	454 (33.2)	91 (6.7)
Gender			
male	455 (55.6)	287 (63.2)	64 (70.3)
female	359 (43.8)	163 (35.9)	27 (29.7)
diverse	5 (0.6)	4 (0.9)	0
Age			
18 - 24	33 (4)	16 (3.5)	2 (2.2)
25 - 34	130 (15.9)	60 (13.2)	13 (14.3)
35 - 44	158 (19.3)	67 (14.8)	19 (20.9)
45 - 54	150 (18.3)	84 (18.5)	14 (15.4)
55 - 64	208 (25.4)	124 (27.3)	26 (28.6)
65 - 74	98 (12)	67 (14.8)	16 (17.6)
75 - 84	39 (4.8)	30 (6.6)	1 (1.1)
>=85	3 (0.4)	6 (1.3)	0
Education			
still in school	5 (0.6)	2 (0.4)	0
primary education	35 (4.3)	17 (3.7)	3 (3.3)
lower secondary education	148 (18.1)	57 (12.6)	19 (20.9)
upper secondary education	631 (77)	378 (83.3)	69 (75.8)
Living conditions			
renter	300 (36.6)	137 (30.2)	29 (31.9)
property owner	519 (63.4)	317 (69.8)	62 (68.1)
Job connected to airport			
direct	14 (1.7)	16 (3.5)	0
indirect	26 (3.2)	15 (3.3)	1 (1.1)
not connected	779 (95.1)	423 (93)	90 (98.9)
Noise exposure			
high exposure (>55 dB(A) L _{den})	452 (55.2)	313 (68.9)	73 (80.2)
low exposure (≤ 55 dB(A) L _{den})	367 (44.8)	141 (31.1)	18 (19.8)
Participation			
online	782 (95.5)	436 (96)	88 (96.7)
paper-pencil	37 (4.5)	18 (4)	3 (3.3)

Note. CGN = Cologne-Bonn Airport, DUS = Dusseldorf Airport and DTM = Dortmund Airport.

Table A.18. Correlation between Fairness Facets and Scales testing Construct Validity for different levels of Noise Exposure

Constructs	Distributive Fairness		Procedural Fairness		Informational Fairness		Interpersonal Fairness	
	low	high	low	high	low	high	low	high
Noise Exposure Level								
Interpersonal Trust (KUSIV3)	-.08	.02	-.00	.04	.01	.06	.07	.06
Political Efficacy (PEKS)								
Internal political efficacy	-.10	-.03	-.18**	-.05	-.02	.04	-.11	-.08
External political efficacy	.12*	.25**	.20**	.29**	.26**	.31**	.23**	.33**
Injustice Sensitivity (USS-8)								
Victim sensitivity	.16*	.19**	.11	.10	.08	.04	.17*	.11*
Observer sensitivity	-.09	-.02	-.11	-.11*	-.06	-.06	-.01	.02
Beneficiary sensitivity	-.00	.05	-.06	.01	-.13*	.00	-.06	.03
Perpetrator sensitivity	-.14*	-.06	-.11	-.11*	-.09	-.06	-.10	-.04
Control Perception (IE-4)								
Internal control perception	-.16*	.02	-.13*	.08	.16**	.10*	.17**	.09
External control perception	.03	.04	.09	-.03	.04	-.07	.02	-.04
Political Cynicism (KPZ)	.04	-.20**	-.13*	-.22**	-.17**	-.27**	-.11	-.27**

Note. *** = $p \leq 0.001$, ** = $p \leq 0.01$, * = $p \leq 0.05$.

Table A.19. Correlation between Fairness Facets and Scales testing Predictive Validity for different levels of Noise Exposure

Construct	Distributive Fairness		Procedural Fairness		Informational Fairness		Interpersonal Fairness	
	low	high	low	high	low	high	low	high
Noise Exposure Level								
Annoyance	-.71**	-.65**	-.64**	-.59**	-.50**	-.54**	-.61**	-.58**
Acceptance	.59**	.60**	.51**	.53**	.43**	.47**	.51**	.51**
Willingness to protest	-.43**	-.46**	-.33**	-.37**	-.20**	-.31**	-.36**	-.44**

Note. *** = $p \leq 0.001$, ** = $p \leq 0.01$, * = $p \leq 0.05$.

Table A.20. fAIR-In Questionnaire in German with Original Items

Inventar zur Erfassung fluglärmbezogener
Fairnesswahrnehmungen

fAIR-In

Dominik Hauptvogel, Dirk Schreckenberger, Tobias Rothmund,
Marie-Therese Schmitz and Susanne Bartels

Zitation:

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Inventar zur Erfassung fluglärmbezogener Fairnesswahrnehmungen (fAIR-In)

Im Folgenden lesen Sie einige Aussagen, die sich auf Aspekte der Nachbarschaftlichkeit beziehen.

Geben Sie an, inwieweit die folgenden Aussagen Ihrer Ansicht nach stimmen oder nicht stimmen.

Sollten Sie Schwierigkeiten haben, eine Frage zu beantworten, wählen Sie die Antwortmöglichkeit, die Ihrer Meinung nach am ehesten zutrifft. Es gibt keine richtigen und falschen Antworten. Uns ist Ihre ganz persönliche Meinung und Wahrnehmung wichtig.

		stimmt nicht	stimmt wenig	stimmt mittelmäßig	stimmt ziemlich	stimmt sehr
1	Der Flughafen bringt mir mehr Vorteile als Nachteile	1	2	3	4	5
2	Der Flughafen investiert ausreichend in Schallschutz, um die Anwohner/innen vor dem Lärm zu schützen.	1	2	3	4	5
3	Durch die unterschiedlichen An- und Abflugrichtungen der Flugzeuge wird die Lärmbelastung gleichmäßig auf die Anwohner/innen verteilt.	1	2	3	4	5
4	Die An- und Abflugrichtungen der Flugzeuge werden so variiert, dass alle Anwohner/innen auch einmal Zeiten der Ruhe genießen können.	1	2	3	4	5
5	Der Flughafen versucht, Anwohner/innen, die bereits von anderem Verkehrslärm (z.B. Straßen- oder Schienenlärm) stark betroffen sind, vor zusätzlicher Belastung durch Fluglärm zu schützen.	1	2	3	4	5
6	Der Flughafen bemüht sich den Fluglärm so zu verteilen, dass Naherholungsgebiete möglichst wenig von Fluglärm betroffen sind.	1	2	3	4	5
7	Die An- und Abflugrichtungen sind so gelegt, dass Schutzbedürftige, wie z.B. Kinder oder kranke Personen, möglichst wenig von Fluglärm betroffen sind.	1	2	3	4	5

8	Bevor Entscheidungen zum Fluglärm getroffen werden, habe ich die Möglichkeit, den Verantwortlichen meine Ansichten mitzuteilen.	1	2	3	4	5
9	Als betroffene/r Anwohner/in werde ich in Entscheidungsprozesse des Flughafenmanagements einbezogen.	1	2	3	4	5
10	Der Flughafen geht in fluglärmrelevanten Entscheidungsprozessen aktiv auf seine Anwohner/innen zu, um deren Ansichten anzuhören.	1	2	3	4	5
11	Wenn Entscheidungen zum Fluglärm getroffen werden, kann ich auf die Ergebnisse des Entscheidungsprozesses Einfluss nehmen.	1	2	3	4	5
12	Als Anwohner/in werde ich bei Entscheidungen, die den Flughafen betreffen, vor vollendete Tatsachen gestellt.	1	2	3	4	5
13	Der Flughafen berücksichtigt bei Entscheidungsprozessen zum Fluglärm die Ansichten seiner Anwohner/innen.	1	2	3	4	5
14	Der Flughafen versucht, Entscheidungen unvoreingenommen und neutral zu treffen.	1	2	3	4	5
15	Bei Entscheidungen zum Fluglärm werden Informationen nur einseitig berücksichtigt.	1	2	3	4	5
16	Alle Parteien, die betroffen sind, werden bei fluglärmrelevanten Entscheidungen mit einbezogen.	1	2	3	4	5
17	In Entscheidungsprozessen zum Fluglärm, werden die Anliegen der betroffenen Anwohner/innen gut vertreten.	1	2	3	4	5
18	Es ist für Anwohner/innen nicht nachvollziehbar, wieso an unterschiedlichen Flughäfen unterschiedliche Regeln gelten, z.B. zu Nachtruhezeiten oder Flugverboten.	1	2	3	4	5
19	In den Entscheidungsprozessen fällen die Verantwortlichen Entscheidungen häufig auf der Basis von falschen Informationen.	1	2	3	4	5

20	Ich habe Möglichkeiten gegen getroffene Entscheidungen, die ich für falsch halte, vorzugehen.	1	2	3	4	5
21	Der Flughafen ist ehrlich bezüglich seiner Pläne für die Zukunft.	1	2	3	4	5
22	Informationen zum Thema Flugverkehr und Fluglärm werden vom Flughafen wahrheitsgemäß berichtet.	1	2	3	4	5
23	Der Flughafen erläutert und begründet fluglärmrelevante Entscheidungen ausführlich.	1	2	3	4	5
24	Der Flughafen kann mir verständlich erläutern, wie er versucht, Fluglärm zu vermeiden.	1	2	3	4	5
25	Wenn ich mich für das Thema Fluglärm interessiere, weiß ich, wo und wie ich durch den Flughafen weitere Informationen erhalte.	1	2	3	4	5
26	Der Flughafen bietet Anlaufstellen, an die ich mich wenden kann wenn ich etwas zum Thema Flugverkehr oder Fluglärm erfahren möchte.	1	2	3	4	5
27	Der Flughafen stellt Informationen bereit, die Anwohner/innen dazu befähigen, mit Lärmverantwortlichen auf Augenhöhe zu diskutieren.	1	2	3	4	5
28	Ich werde als Anwohner/in mit meinen Anliegen beim Flughafen ernst genommen.	1	2	3	4	5
29	Der Flughafen bemüht sich um einen Austausch mit lärmbeeinträchtigten Anwohner/innen, der auf Augenhöhe geführt wird.	1	2	3	4	5
30	Der Flughafen zeigt aufrichtiges Verständnis für die Sorgen lärmbeeinträchtigter Anwohner/innen.	1	2	3	4	5
31	Der Flughafen versucht, auf die individuellen Bedürfnisse der Anwohner/innen einzugehen.	1	2	3	4	5
32	Der Austausch zwischen Flughafen und Anwohner/innen ist respektvoll.	1	2	3	4	5

Zusammenfassung

Der fAIR-In erhebt Aspekte der distributiven, prozeduralen, informationalen und interpersonalen Fairness in Bezug auf die Beziehung zwischen Flughafen und betroffenen AnwohnerInnen. Nicht-akustische Faktoren haben einen erheblichen Einfluss auf die Intensität der empfundenen FluglärmBelästigung. Fairness wurde als ein Faktor identifiziert, der vielen dieser nicht-akustischen Faktoren zugrunde liegt. Die Items des Fragebogens basieren auf Forschungsergebnissen zu Fairness aus anderen Kontexten (z. B. Adams, 1965; Bies & Moag, 1986; Greenberg, 1993; Leventhal, 1980) und auf Interviews mit von Fluglärm betroffenen AnwohnerInnen. Mit Hilfe des Fragebogens kann die Wahrnehmung des Flughafenmanagements aus Sicht der AnwohnerInnen erfasst und konkrete Ansatzpunkte für Interventionen mit dem Ziel, die Nachbarschaftlichkeit zwischen Flughafen und AnwohnerInnen zu verbessert, formuliert werden. Die Anwendung des Fragebogens vor, während und nach einer Interventionen ist zu empfehlen, um den aktuellen Stand, sowie den Erfolg nach einer durchgeführten Intervention zu erheben.

Antwortskala

5-Punkte Likert Scale: 1 = stimmt nicht, 2 = stimmt wenig, 3 = stimmt mittelmäßig, 4 = stimmt ziemlich, 5 = stimmt sehr

Werte nahe bei 5 deuten darauf hin, dass der Flughafen als fair empfunden wird. Werte nahe bei 1 deuten darauf hin, dass die Beziehungen zwischen dem Flughafen und den Anwohnern unzureichend sind.

Auswertungshinweise:

Für die Auswertung kann der Skalenwert (zwischen 1 und 5) für jedes beantwortete Item und jeden / jede Teilnehmer/in summiert und durch die Gesamtzahl der Antworten geteilt und dann gerundet werden.

Eine Teilanwendung und -auswertung auf der Ebene der Subskalen ist zulässig, da es sich um reliable und valide Subskalen handelt. Bitte beachten Sie die entsprechende Item Zuordnung.

Hinweis:

In der Fairness-Forschung wurden die verschiedenen Subfacetten als unabhängige Faktoren identifiziert, sie stehen jedoch in einer wechselseitigen Beziehung zueinander. Um ein faires, nachbarschaftliches Verhältnis zu den BewohnerInnen aufzubauen, ist daher ein ganzheitlicher Ansatz erforderlich, der alle Facetten gleichermaßen berücksichtigt.

Umsetzung der Testergebnisse im Flughafenmanagement:

Für die Umsetzung der Ergebnisse im Sinne eines fairen, nachbarschaftlichen Umgangs gibt es keine grundsätzlichen Empfehlungen und es müssen je nach Kontext und Charakteristik des Flughafens individuelle Entscheidungen getroffen werden.

Es lassen sich jedoch Grundprinzipien ableiten, die sich auf die aktuelle Fairness-Forschung beziehen.

Eine Übersicht und Diskussion möglicher Interventionen, die individuelle Fairness-Aspekte einbeziehen, findet sich in dem Review von Hauptvogel et al. (2021).

Table A.21. fAIR-In Questionnaire translated into English

Aircraft Noise related Fairness Inventory

fAIR-In

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Marie-Therese Schmitz and Susanne Bartels

Citation:

Hauptvogel, D., Schreckenberger, D., Rothmund, T., Schmitz, M.T., Bartels, S. (2023). Being a Fair Neighbor – Towards a Psychometric Inventory to Assess Fairness-Related Perceptions of the Airport by Residents – Development and Validation of the Aircraft Noise related Fairness Inventory (fAIR-In). *Int. J. Environ. Res. Public Health* 2023

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Below you will read several statements that relate to aspects of neighborliness.

Please indicate to what extent you think the following statements are true or not true.

If you have difficulty answering a question, choose the answer option that you think is most appropriate. There are no right and wrong answers. Your personal opinion and perception are important to us.

		Not true	A Little true	Moderately true	Quite a bit true	Very true
1	The airport brings me more advantages than disadvantages.	1	2	3	4	5
2	The airport invests sufficiently in noise protection to protect residents from the noise.	1	2	3	4	5
3	Due to the different approach and departure routes of the aircraft, the noise exposure is evenly distributed among the residents.	1	2	3	4	5
4	The approach and departure routes of the aircraft are varied in such a way that all residents can also enjoy periods of peace and quiet.	1	2	3	4	5
5	The airport attempts to protect residents who are already affected by other traffic noise (e.g. road or rail noise) from further exposure to aircraft noise.	1	2	3	4	5
6	The airport strives to distribute aircraft noise in such a way that local recreation areas are affected as little as possible by aircraft noise.	1	2	3	4	5
7	The approach and departure routes are designed in such a way that those in need of special protection, such as children or sick individuals, are affected as little as possible by aircraft noise.	1	2	3	4	5
8	Before decisions are made on aircraft noise, I have the opportunity to make my views known to those responsible.	1	2	3	4	5
9	As an affected resident, I am involved in the decision-making process of the airport management.	1	2	3	4	5
10	The airport actively approaches its residents in decision-making processes	1	2	3	4	5

	regarding aircraft noise to listen to their opinions.					
11	When decisions are made about aircraft noise, I can influence the outcome of the decision-making process.	1	2	3	4	5
12	As a resident, I am presented with a fait accompli when it comes to decisions concerning the airport.	1	2	3	4	5
13	The airport takes the views of its residents into account in decision-making processes regarding aircraft noise.	1	2	3	4	5
14	The airport attempts to make decisions in an impartial and neutral manner.	1	2	3	4	5
15	In decisions on aircraft noise, information is only taken into account from one perspective.	1	2	3	4	5
16	All affected parties are involved in decisions regarding aircraft noise.	1	2	3	4	5
17	In decision-making processes regarding aircraft noise, the concerns of affected residents are well represented.	1	2	3	4	5
18	It is not understandable for residents why different rules apply at different airports, e.g. on night curfews or flight bans.	1	2	3	4	5
19	In the decision-making processes, those in charge often reach decisions on the basis of incorrect information.	1	2	3	4	5
20	I have possibilities to take action against decisions that I think are wrong.	1	2	3	4	5
21	The airport is honest about its plans for the future.	1	2	3	4	5
22	Information on air traffic and aircraft noise is reported truthfully by the airport.	1	2	3	4	5
23	The airport explains and justifies decisions relevant to aircraft noise in detail.	1	2	3	4	5
24	The airport can explain to me in an understandable way how it tries to avoid aircraft noise.	1	2	3	4	5

25	If I am interested in the topic of aircraft noise, I know where and how to get more information through the airport.	1	2	3	4	5
26	The airport offers contact points that I can turn to if I want to know something about air traffic or aircraft noise.	1	2	3	4	5
27	The airport provides information that enables residents to discuss with noise authorities at eye level.	1	2	3	4	5
28	As a resident, my concerns are taken seriously by the airport.	1	2	3	4	5
29	The airport strives for an exchange with noise-affected residents that is conducted on an equal footing.	1	2	3	4	5
30	The airport shows genuine understanding for the concerns of residents affected by noise.	1	2	3	4	5
31	The airport tries to respond to the individual needs of the residents.	1	2	3	4	5
32	The exchange between airport and residents is respectful.	1	2	3	4	5

Note. Rating scale was translated from German into English according to Rohrmann (2007)) and can be seen as approximately interval scaled.

Summary

The fAIR-In measures aspects of distributive, procedural, informational and interpersonal fairness in relation to the relationship between the airport and affected residents.

Non-acoustic factors have a significant impact on the intensity of aircraft noise annoyance experienced. Fairness was identified as an underlying factor of a number of non-acoustic factors.

The items of the questionnaire are based on research on fairness in other contexts (e.g. Adams, 1965; Bies & Moag, 1986; Greenberg, 1993; Leventhal, 1980) and on interviews with residents affected by aircraft noise.

With the help of the questionnaire, the perception of the airport management from the residents' point of view can be captured, and concrete starting points for interventions can be formulated with the aim of increasing the neighborliness between airport and residents. It is helpful to use the questionnaire during an intervention, as well as in pre- and post-comparison to measure the success of interventions.

Response specifications

5-point Likert Scale: 1 = not true, 2 = a little true, 3 = moderately true, 4 = quite a bit true, 5 = very true

Values close to 5 indicate a perception of the airport as being fair. Values close to 1 indicate that there are deficiencies in the relationship between the airport and residents.

Evaluation instructions:

For evaluation, the scale value (between 1 and 5) for each answered item and respondent can be summed and divided by the total number of responses and then rounded.

Partial application and evaluation is acceptable at the subscale level, as these are reliable and valid subscales. Please note the corresponding item assignment.

Note:

In research on fairness, the various subfacets have been identified as independent factors, but they are mutually interrelated. A holistic approach is therefore needed to establish a fair, neighborly relationship with residents that takes all facets into account equally.

Implementation of the test results in airport management:

For the implementation of the results in the sense of a fair, neighborly relationship, there are no basic recommendations and individual decisions must be taken depending on the context and characteristics of the airport.

However, basic principles can be derived that relate to current research on fairness.

An overview and discussion of potential interventions that include individual fairness aspects can be found in the review by Hauptvogel et al. (2021).

Table A.22. fAIR-In Items in German and English with classification to facets and subfacets**Facet description**

D = Distributive

P = Procedural

IF = Informational

IP = Interpersonal

Nr	Item in German	Items in English	Polarisation	Facette	Subfacette
1	Der Flughafen bringt mir mehr Vorteile als Nachteile	The airport brings me more advantages than disadvantages.	+	D	Equity
2	Der Flughafen investiert ausreichend in Schallschutz, um die Anwohner/innen vor dem Lärm zu schützen.	The airport invests sufficiently in noise protection to protect residents from the noise.	+	D	Equity
3	Durch die unterschiedlichen An- und Abflugrichtungen der Flugzeuge wird die Lärmbelastung gleichmäßig auf die Anwohner/innen verteilt.	Due to the different approach and departure routes of the aircraft, the noise exposure is evenly distributed among the residents.	+	D	Equality
4	Die An- und Abflugrichtungen der Flugzeuge werden so variiert, dass alle Anwohner/innen auch einmal Zeiten der Ruhe genießen können.	The approach and departure routes of the aircraft are varied in such a way that all residents can also enjoy periods of peace and quiet.	+	D	Equality
5	Der Flughafen versucht, Anwohner/innen, die bereits von anderem Verkehrslärm (z.B. Straßen- oder Schienenlärm) stark betroffen sind, vor zusätzlicher Belastung durch Fluglärm zu schützen.	The airport attempts to protect residents who are already affected by other traffic noise (e.g. road or rail noise) from further exposure to aircraft noise.	+	D	Need
6	Der Flughafen bemüht sich den Fluglärm so zu verteilen, dass Naherholungsgebiete möglichst wenig von Fluglärm betroffen sind.	The airport strives to distribute aircraft noise in such a way that local recreation areas are affected as little as possible by aircraft noise.	+	D	Need

7	Die An- und Abflugrichtungen sind so gelegt, dass Schutzbedürftige, wie z.B. Kinder oder kranke Personen, möglichst wenig von Fluglärm betroffen sind.	The approach and departure routes are designed in such a way that those in need of special protection, such as children or sick individuals, are affected as little as possible by aircraft noise.	+	D	Need
8	Bevor Entscheidungen zum Fluglärm getroffen werden, habe ich die Möglichkeit, den Verantwortlichen meine Ansichten mitzuteilen.	Before decisions are made on aircraft noise, I have the opportunity to make my views known to those responsible.	+	P	Process Control
9	Als betroffene/r Anwohner/in werde ich in Entscheidungsprozesse des Flughafens einbezogen.	As an affected resident, I am involved in the decision-making process of the airport management.	+	P	Process Control
10	Der Flughafen geht in fluglärmrelevanten Entscheidungsprozessen aktiv auf seine Anwohner/innen zu, um deren Ansichten anzuhören.	The airport actively approaches its residents in decision-making processes regarding aircraft noise to listen to their opinions.	+	P	Process Control
11	Wenn Entscheidungen zum Fluglärm getroffen werden, kann ich auf die Ergebnisse des Entscheidungsprozesses Einfluss nehmen.	When decisions are made about aircraft noise, I can influence the outcome of the decision-making process.	+	P	Decision Control
12	Als Anwohner/in werde ich bei Entscheidungen, die den Flughafen betreffen, vor vollendete Tatsachen gestellt.	As a resident, I am presented with a fait accompli when it comes to decisions concerning the airport.	-	P	Decision Control
13	Der Flughafen berücksichtigt bei Entscheidungsprozessen zum Fluglärm die Ansichten seiner Anwohner/innen.	The airport takes the views of its residents into account in decision-making processes regarding aircraft noise.	+	P	Decision Control
14	Der Flughafen versucht, Entscheidungen unvoreingenommen und neutral zu treffen.	The airport attempts to make decisions in an impartial and neutral manner.	+	P	Bias Suppression
15	Bei Entscheidungen zum Fluglärm werden	In decisions on aircraft noise, information is only	-	P	Bias Suppression

	Informationen nur einseitig berücksichtigt.	taken into account from one perspective.			
16	Alle Parteien, die betroffen sind, werden bei fluglärmrelevanten Entscheidungen mit einbezogen.	All affected parties are involved in decisions regarding aircraft noise.	+	P	Representativeness
17	In Entscheidungsprozessen zum Fluglärm, werden die Anliegen der betroffenen Anwohner/innen gut vertreten.	In decision-making processes regarding aircraft noise, the concerns of affected residents are well represented.	+	P	Representativeness
18	Es ist für Anwohner/innen nicht nachvollziehbar, wieso an unterschiedlichen Flughäfen unterschiedliche Regeln gelten, z.B. zu Nachtruhezeiten oder Flugverboten.	It is not understandable for residents why different rules apply at different airports, e.g. on night curfews or flight bans.	-	P	Consistency
19	In den Entscheidungsprozessen fällen die Verantwortlichen Entscheidungen häufig auf der Basis von falschen Informationen.	In the decision-making processes, those in charge often reach decisions on the basis of incorrect information.	-	P	Accuracy
20	Ich habe Möglichkeiten gegen getroffene Entscheidungen, die ich für falsch halte, vorzugehen.	I have possibilities to take action against decisions that I think are wrong.	+	P	Correctability
21	Der Flughafen ist ehrlich bezüglich seiner Pläne für die Zukunft.	The airport is honest about its plans for the future.	+	IF	Truthfulness
22	Informationen zum Thema Flugverkehr und Fluglärm werden vom Flughafen wahrheitsgemäß berichtet.	Information on air traffic and aircraft noise is reported truthfully by the airport.	+	IF	Truthfulness
23	Der Flughafen erläutert und begründet fluglärmrelevante Entscheidungen ausführlich.	The airport explains and justifies decisions relevant to aircraft noise in detail.	+	IF	Justification

24	Der Flughafen kann mir verständlich erläutern, wie er versucht, Fluglärm zu vermeiden.	The airport can explain to me in an understandable way how it tries to avoid aircraft noise.	+	IF	Justification
25	Wenn ich mich für das Thema Fluglärm interessiere, weiß ich, wo und wie ich durch den Flughafen weitere Informationen erhalte.	If I am interested in the topic of aircraft noise, I know where and how to get more information through the airport.	+	IF	Empowerment
26	Der Flughafen bietet Anlaufstellen, an die ich mich wenden kann wenn ich etwas zum Thema Flugverkehr oder Fluglärm erfahren möchte.	The airport offers contact points that I can turn to if I want to know something about air traffic or aircraft noise.	+	IF	Empowerment
27	Der Flughafen stellt Informationen bereit, die Anwohner/innen dazu befähigen, mit Lärmverantwortlichen auf Augenhöhe zu diskutieren.	The airport provides information that enables residents to discuss with noise authorities at eye level.	+	IF	Empowerment
28	Ich werde als Anwohner/in mit meinen Anliegen beim Flughafen ernst genommen.	As a resident, my concerns are taken seriously by the airport.	+	IP	Propriety
29	Der Flughafen bemüht sich um einen Austausch mit lärmbeeinträchtigten Anwohner/innen, der auf Augenhöhe geführt wird.	The airport strives for an exchange with noise-affected residents that is conducted on an equal footing.	+	IP	Propriety
30	Der Flughafen zeigt aufrichtiges Verständnis für die Sorgen lärmbeeinträchtigter Anwohner/innen.	The airport shows genuine understanding for the concerns of residents affected by noise.	+	IP	Propriety
31	Der Flughafen versucht, auf die individuellen Bedürfnisse der Anwohner/innen einzugehen.	The airport tries to respond to the individual needs of the residents.	+	IP	Respect
32	Der Austausch zwischen Flughafen und Anwohner/innen ist respektvoll.	The exchange between airport and residents is respectful.	+	IP	Respect

Table A.23. Questionnaire used to measure Acceptance of the Airport and Air travel

Questioning	Items in German	Items in English	Polarization	Answers
Ich halte den Flugverkehr ganz allgemein für...	notwendig	necessary	+	Stimmt nicht
	gesundheitsgefährdend	harmful	-	Stimmt wenig
	unsicher	unsafe	-	Stimmt mittelmäßig
				Stimmt ziemlich
I consider air traffic in general to be...	umweltschädlich	Environmentally damaging	-	Stimmt sehr
	vermeidbar	avoidable	-	Not true
	schlecht für die Luftqualität	Bad for air quality	-	A little true
				Moderately true
	klimaschädlich	climate damaging	-	Quite a bit true
			Very true	

Table A.24. Questionnaire used in this study to measure Protest Behavior.

Questioning	Items in German	Items in English	Answers
Haben/Sind Sie im Zusammenhang mit der Fluglärmenthematik...	... eine Protestliste, Petition oder Ähnliches unterschrieben?	... signed a protest list, petition or similar?	Nein
	... Kontakt zum Flughafen oder einer zuständigen Stelle aufgenommen, um Informationen zu erhalten?	... contacted the airport or a responsible office for information?	Ja
	... Kontakt zum Flughafen oder einer zuständigen Stelle aufgenommen, um sich zu beschweren?	... Have you contacted the airport or a competent authority to complain?	<i>Wert ergibt sich aus der Summe positiv beantworteter Aussagen.</i>
In connection with the aircraft noise topic, have you...	... einer Bürgerinitiative gegen Fluglärm beigetreten?	... joined a citizens' initiative against aircraft noise?	No
			Yes

... an einer Demonstration
teilgenommen?

... participated in a
demonstration?

*Value results from the
sum of positively
answered statements.*

... in ein anderes Gebiet gezogen?

... moved to another
area?

(falls nein) Ziehen Sie einen
Umzug in Betracht?

(if no) are you
considering moving?

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Declaration

Hiermit erkläre ich, Dominik Hauptvogel, dass mir die Promotionsordnung der Fakultät für Sozial- und Verhaltenswissenschaften der Friedrich-Schiller-Universität Jena bekannt ist. Ich habe die vorgelegte Dissertation selbstständig und ohne unerlaubte fremde Hilfe sowie nur mit den Hilfen angefertigt, die ich in der Dissertation angegeben habe. Alle Textstellen eines Dritten oder eigener Prüfungsarbeiten, die wörtlich oder sinngemäß aus veröffentlichten Schriften entnommen sind, sind als solche kenntlich gemacht. Ich habe weder die Hilfe eines kommerziellen Promotionsvermittlers in Anspruch genommen, noch haben Dritte weder unmittelbar oder mittelbar geldwerte Leistungen von mir für Arbeiten erhalten, die im Zusammenhang mit dem Inhalt der vorgelegten Dissertation stehen. Ich habe die vorliegende Dissertation nicht, auch nicht in Teilen, für eine staatliche oder wissenschaftliche Prüfung bzw. als Dissertationsschrift bei einer anderen Hochschule bzw. Fakultät eingereicht.

Dominik Hauptvogel – Köln, den 2. November 2023