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Aircraft Noise related Fairness Inventory – Development and Validation of a Psychometric Instrument

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ABSTRACT

Aircraft noise annoyance is significantly impacted by non-acoustic factors such as an individuals' attitude towards the noise source, perceived control over the noise and predictability of noise events. The concept of perceived fairness has been introduced into the context of aircraft noise research as an underlying construct of many of these non-acoustic factors. For instance, the assessment of noise and its source may depend on the perceived fairness of the noise distribution, the information provided by the noise source and opportunities for noise-affected individuals to participate in noise-related decision-making. So far, a validated instrument to assess a broad range of fairness aspects in surveys has been lacking. For this purpose, the Aircraft Noise related Fairness Inventory (fAIR-In), a multifaceted psychometric instrument, has been developed. Via 32 items, the fAIR-In assesses the fairness of aircraft noise and airport management from the perspective of the four facets distributive, procedural, informational and interpersonal fairness. The development and validation process based on a survey with 1,367 residents living around three airports in Germany is reported. Results of the validation process confirm the four-factor structure of fairness and show high predictive validity regarding annoyance, airport and air travel acceptance as well as protest behavior. We conclude that the fAIR-In is a useful instrument to capture existing community perceptions of the airport and for the design, monitoring and evaluation of measures aimed at building a better neighbourly relationship between the airport and local residents.

Keywords: Fairness, Aircraft Noise, Annoyance, Non-Acoustic Factors, Questionnaire

INTRODUCTION

Long-term noise exposition from aircraft has been found to have significant negative effects on human health, including annoyance [1], sleep disturbance [2], cardiovascular problems [3], and mental health issues [4]. Children are also negatively impacted by noise pollution, with a decrease in reading and oral comprehension [5]. Annoyance is considered as one of the most important consequences of noise pollution, as it not only affects individuals' quality of life but also mediates between noise and health risks. Highly annoyed individuals are at greater risk of hypertension [6], psychological distress [7], depression [8], mental well-being [9] and the use of medication to treat anxiety [10]

Reducing annoyance is therefore crucial to minimizing the long-term consequences of aircraft noise. While aircraft noise is certainly responsible for the development of annoyance, the degree of annoyance is largely determined by non-acoustic factors, including individuals' attitude towards the noise source, perceived control over the noise and predictability of noise events [11].

The concept of perceived fairness has been introduced into the context of aircraft noise research as an underlying construct of many of these non-acoustic factors. For instance, the assessment of noise and its source may depend on the perceived fairness of the noise distribution, the information provided by the noise source and opportunities for noise-affected individuals to participate in noise-related decision-making

So far, a validated instrument to assess a broad range of fairness aspects in surveys has been lacking. For this purpose, the Aircraft Noise-related Fairness Inventory (fAIR-In), a multifaceted psychometric instrument, has been developed. Such a tool would be a useful instrument for capturing existing community perceptions of the airport and for the design, monitoring and evaluation of measures aimed at building a better neighborly relationship between the airport and local residents.

MATERIALS AND METHODS

Study Design

The cross-sectional study was conducted using an online survey format and targeted residents living around the airports in Cologne-Bonn, Düsseldorf, and Dortmund, which are located in the German federal state of Northrine-Westphalia. The study regions were selected to include both areas with high exposure to aircraft noise (> 55 dB(A) L_{den}) and regions with lower exposure (< 55 dB(A) L_{den}). Noise pollution was determined using freely available environmental noise maps for North Rhine-Westphalia, which were published by the Ministry for the Environment, Nature Protection, and Transport of the State of North Rhine-Westphalia [12].

A total of 99,921 survey invitations were distributed by mail between September and October 2021, with 44,134 sent to residents in high-noise-exposure areas and 55,787 to those in lower-noise-exposure areas. After removing incomplete responses, 1,367 complete datasets were available for further analysis. The complete dataset was randomly divided into two equal parts to conduct item selection and assess model quality.

Fairness Items

To develop items for measuring perceptions of fairness related to airport management, three methods were utilized. Firstly, a critical incident technique was used, with input from scientific experts and airport authorities, to identify specific situations that exemplified fairness-related concerns. Secondly, existing measurement instruments from organizational psychology and other domains were reviewed for relevant items [13-16]. Lastly, focus groups conducted within the EU-project ANIMA with affected residents living near airports were re-analyzed to generate additional items [17].

A total of 68 items were created and classified into four categories, namely distributive fairness, procedural fairness, informational fairness, and interpersonal fairness, with each category having its respective sub-facets.

During the development process of the fAIR-In, 29 of the original 68 items were excluded in order to maximize internal consistency at the sub-facet level. Redundant or comparable items were excluded first, followed by items that did not align with the original idea from the literature and had high numbers of omitted answers. An additional factor analysis was performed to investigate the factor loadings of items to their respective fairness facet, resulting in the elimination of a further seven items that had low factor loadings, high cross-loadings on more than one factor, and low communalities. The final number of items remaining in the fAIR-In survey after the complete analysis was 32.

Additional scales

In order to assess the validity of the fAIR-In, the respondents were presented with additional scales to answer. To measure predictive validity, the survey assessed the willingness to protest in the context of the aircraft noise issue, aircraft noise annoyance [18], and acceptance of the airport and air traffic.

RESULTS

Reliability of the scale

The 32 items assessing distributive, procedural, informational, and interpersonal fairness exhibit high internal consistency, as evidenced by McDonald's Omega (ω) coefficients ranging from 0.89 to 0.92 and accounting for 63.8% of the variance.

Predictive Validity

The study examined the correlations between fairness facets and predictive variables. Results indicated that all fairness facets were negatively related to annoyance, ranging from moderate to strong. Fairness and acceptance of the airport and air traffic were positively related, ranging from moderate to strong. Furthermore, there was a negative correlation between willingness to protest and all fairness facets, ranging from weak to moderate.

DISCUSSION

In summary, the development process of the Aircraft Noise related Fairness Inventory (fAIR-In) involved several steps, such as item generation through literature search, expert interviews, and focus groups, as well as item selection based on statistical analyses of a large-scale online survey of airport residents. The predictive validity of the fAIR-In was then assessed through correlations with relevant variables such as annoyance, acceptance, and willingness to protest. As hypothesized, all fairness facets were found to be highly correlated

with these variables, with perceived airport fairness showing negative relationships with annoyance and positive relationships with acceptance and willingness to protest. These results confirm the usefulness of the fAIR-In as a practical evaluation tool for airport management.

CONCLUSION

This paper presents the fAIR-In, a validated psychometric instrument that can be used to assess the relationship between airports and residents. The goal is to establish a foundation for addressing concerns, improving relationships, and creating a fairer and more trusting relationship between airport operators and residents in the long term. The fAIR-In can also provide essential support for implementing interventions in airport management. By identifying which aspects of fairness are perceived positively or negatively, targeted and efficient interventions can be planned to increase perceived fairness and build neighborly relationships. The fAIR-In also offers a low-cost and quick-to-implement tool for evaluating implemented interventions, which can help close the current gap in airport activities evaluation. The early integration of fairness seems crucial to minimize negative consequences for residents whenever noise scenarios are subject to changes. As aircraft noise is a man-made noise, unlike natural noise sources, aspects addressed by the fAIR-In can be applied to other scenarios involving noise sources such as wind turbines, heat pumps, drones, or air taxi noise.

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