

# **Beyond status quo: The role of behavioral factors and familiarity in low-carbon decision-making**

DISSERTATION  
of the University of St.Gallen,  
School of Management,  
Economics, Law, Social Sciences,  
International Affairs and Computer Sciences,  
to obtain the title of  
Doctor of Philosophy in  
International Affairs and Political Economy

submitted by

**Nathalie Dällenbach**

from

Signau (Berne)

Approved on the application of

**Prof. Dr. Rolf Wüstenhagen**

and

**Prof. Dr. Nina Hampl**

Dissertation no. 5099

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**Susana Batel, PhD**

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The University of St.Gallen, School of Management, Economics, Law, Social Sciences, International Affairs and Computer Science, hereby consents to the printing of the present dissertation, without hereby expressing any opinion on the views herein expressed.

St.Gallen, May 20, 2021

The President:

Prof. Dr. Bernhard Ehrenzeller

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## List of abbreviations and symbols

|                 |                                                                                |
|-----------------|--------------------------------------------------------------------------------|
| ATAG            | Air Transport Action Group                                                     |
| °C              | Degree Celsius                                                                 |
| COP             | Conference of Parties                                                          |
| CO <sub>2</sub> | Carbon dioxide                                                                 |
| dB              | Decibels                                                                       |
| dB(A)           | A-weighted decibel levels                                                      |
| DETEC           | Federal Department of the Environment, Transport,<br>Energy and Communications |
| FOCA            | Federal Office of Civil Aviation                                               |
| FOEN            | Federal Office for the Environment                                             |
| GWh             | Gigawatt hour                                                                  |
| IEA             | International Energy Agency                                                    |
| IPCC            | Intergovernmental Panel on Climate Change                                      |
| IRENA           | International Renewable Energy Agency                                          |
| km              | Kilometer                                                                      |
| LCA             | Low-cost airlines                                                              |
| m               | Meter                                                                          |
| MW              | Megawatt                                                                       |
| kWh             | Kilowatt hour                                                                  |
| PV              | Photovoltaic                                                                   |
| SBB             | Swiss national railways                                                        |

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|             |                                                                                                           |
|-------------|-----------------------------------------------------------------------------------------------------------|
| SCCER CREST | Swiss Competence Center for Energy Research -<br>Center for Research in Energy, Society and<br>Transition |
| SFOE        | Swiss Federal Office for Energy                                                                           |
| UNFCCC      | United Nations Framework Convention on Climate<br>Change                                                  |
| WHO         | World Health Organization                                                                                 |

## List of statistical abbreviations and symbols

|          |                                             |
|----------|---------------------------------------------|
| ANOVA    | Analysis of variance                        |
| B        | Unstandardized beta                         |
| df       | Degrees of freedom                          |
| Exp(B)   | Odds ratio                                  |
| F        | F-Statistic                                 |
| IAT      | Implicit Association Test                   |
| M        | Arithmetic mean                             |
| n        | Sample size per group                       |
| N        | Total sample size                           |
| p        | Error probability                           |
| RQ       | Research question                           |
| SD       | Standard deviation                          |
| SE       | Standard error                              |
| SPSS     | Statistical package for the social sciences |
| t        | t-statistic                                 |
| $\chi^2$ | Chi-square                                  |

## Abstract

Moving beyond the status quo towards low-carbon energy and transportation systems is central to halting global climate change. From a technical point of view, numerous low-carbon solutions are available. However, a successful energy transition also hinges on community- and consumer-level decisions to adopt climate-friendly alternatives. As such, accelerating low-carbon transitions requires in-depth knowledge on how to foster social acceptance of renewable energy projects and low-carbon mobility behaviors. The findings of this dissertation highlight that gaining familiarity with sustainable alternatives and considering other behavioral factors such as emotions may be decisive in successfully implementing climate-friendly solutions. This overarching theme is explored in three different papers.

Paper 1 focuses on community-level decisions, specifically on the social acceptance of wind energy projects. It investigates how and why wind turbine sound concerns arise and unfold during a wind project's planning phase. Results show that noise concerns travel much farther than actual wind turbine noise. Project leaders and policymakers should tend to those residents living closest to the wind turbine, as their concerns may be rationally founded, and to those unfamiliar with wind turbine sound, as they are prone to overestimating wind turbine impacts.

Papers 2 and 3 focus on consumer-level decisions in the transportation sector. They provide insights into the psychological factors of long-distance travel mode choices between air travel and its low-carbon alternative train travel.

Paper 2 shows that being familiar with train travel and highly valuing the productive use of travel time result in a higher likeliness of choosing train over air travel. The paper proposes two strategies to increase familiarity with train travel and suggests that railway's communication messages should emphasize the productive use of travel time.

Paper 3 reveals that implicit affective associations are more strongly related to continental travel preferences (plane vs. train) than environmental attitudes. These results highlight that policy makers and business leaders should go beyond appealing to the public about the environmental impact of air travel and also consider the emotional dimension of travel mode choices.

## Zusammenfassung

Um den globalen Klimawandel aufzuhalten, ist es zentral, uns vom Status quo zu verabschieden und CO<sub>2</sub>-arme Energie- und Transportsysteme zu fördern. Aus technischer Sicht sind bereits zahlreiche klimafreundliche Lösungen verfügbar. Ein erfolgreicher Energiewandel bedingt jedoch auch nachhaltige Konsumenten- und Bürgerentscheidungen. Somit setzt die Beschleunigung des Wandels hin zu einer kohlenstoffarmen Zukunft ein fundiertes Wissen über die Treiber und Barrieren voraus, die die soziale Akzeptanz erneuerbarer Energien und nachhaltiges Mobilitätsverhalten fördern resp. hemmen. Die Ergebnisse zeigen, dass die Vertrautheit mit nachhaltigen Alternativen und andere Verhaltensfaktoren wie Emotionen die erfolgreiche Umsetzung klimafreundlicher Lösungen entscheidend beeinflussen. Die vorliegende Dissertation besteht aus drei Forschungsarbeiten.

Der erste Beitrag setzt den Fokus auf die soziale Akzeptanz von Windenergieprojekten und verbessert somit das Verständnis von Bürgerentscheidungen auf Gemeindeebene. Es wird untersucht, inwiefern und warum während der Planungsphase eines Windprojekts Lärmsorgen auftreten. Die Ergebnisse zeigen, dass Lärmbedenken weit über den tatsächlichen Windturbinenlärm hinaus reichen. Projektleiter und politische Entscheidungsträger sollten sich primär um Anwohner kümmern, die im engsten Umkreis der Windturbine wohnen, denn ihre Bedenken könnten gut begründet sein. Beachtung sollte aber auch denjenigen geschenkt werden, die mit Windturbinen wenig vertraut sind, und dazu neigen, die Lärmbelastung zu überschätzen.

Die zweite und die dritte Forschungsarbeit konzentrieren sich auf Konsumentenentscheidungen im Transportsektor. Sie untersuchen die Rolle von Verhaltensfaktoren bei der Wahl zwischen Flug- und Zugreisen und wie letztere als kohlenstoffarme Alternative gefördert werden können.

Der zweite Beitrag zeigt, dass Personen, die mit dem Zugfahren vertraut sind und die produktive Nutzung der Reisezeit schätzen, dazu neigen, den Zug dem Flugzeug vorzuziehen. Das Papier empfiehlt zwei Strategien, um die Vertrautheit mit Bahnreisen zu erhöhen. Zusätzlich wird empfohlen, bei der Kommunikation die produktive Nutzung der Reisezeit während der Zugfahrt hervorzuheben.

Der dritte Beitrag zeigt, dass implizite affektive Assoziationen mit Flugreisen stärker mit kontinentalen Flug- und Bahnreiseppräferenzen zusammenhängen als

umweltbezogene Einstellungen. Dieses zentrale Ergebnis zeigt, dass politische und wirtschaftliche Entscheidungsträger über die Sensibilisierung der Öffentlichkeit bezüglich der Umweltauswirkungen von Flugreisen hinausgehen sollten, indem sie die emotionale Dimension der Wahl des Reisemodus berücksichtigen.

# Introductory chapter<sup>1</sup>

## 1 Research background and problem statement

In December 2015, 195 countries reached consensus to limit global warming between 1.5°C and well below 2°C, compared to pre-industrial levels (UNFCCC, 2015). Three years later, parties approved of the Intergovernmental Panel on Climate Change (IPCC) 1.5°C report at the Conference of Parties (COP) 24 in Katowice, highlighting the urgency for ambitious mitigation measures (IPCC, 2018; COP 24, 2018). Pathways to limiting global warming to 1.5°C require a wide-ranging rethinking of energy, land, urban and industrial systems (IPCC, 2018, p. 15). According to the proposed pathways, it is imperative to ensure a strong upscaling of renewables to decarbonize the electricity system in a first step (Davis, 2010; Clarke et al., 2014; Rogelj et al., 2015; Rogelj et al., 2018), which makes up the largest share (42%) of global CO<sub>2</sub> emissions (IEA, 2021). This central pillar provides a valuable basis for CO<sub>2</sub> reductions in end-user sectors, including building, transportation and industry, for example, through the electrification of low-carbon transportation systems (Rogelj et al., 2018).

Climate policies' original emphasis on the power sector has resulted in promising deployment rates of low-carbon technologies such as wind and solar energy, which are now mature and cost-competitive (Lazard, 2020; IRENA, 2020). Between 2019 and 2025, renewables could account for 95% of net power capacity additions globally, whereby solar and wind are forecasted to surpass the total installed power capacity of natural gas in 2023 and coal in 2024 (IEA, 2020a). With increasing attention given to the 1.5°C target, the focus is now also quickly expanding to end-user sectors for which low-carbon solutions are less developed (IRENA, 2020). In the transportation sector, electric vehicles are becoming attractive to consumers from a cost-perspective as battery prices are expected to further decline over the next years (Miotti et al., 2016; BloombergNEF, 2020; Miotti & Trancik, 2021). A major challenge are the most energy-intensive sectors, including heavy industry and long-haul transport, for which technological solutions are still far from mature (IRENA, 2020). For example, in the

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<sup>1</sup> Note that the introductory chapter introduces and summarizes the three papers of this doctoral thesis. Thus, several sections draw on the content of Paper 1, Paper 2 and Paper 3 without explicit citation.

long-haul transportation sector, zero-emission aircraft will enter the commercial market earliest by 2030 (FOCA, 2020; Wright Electric, 2020; Airbus, 2020).

The global climate agreement provides room for a wide range of mitigation strategies at the national level, tailored to countries' specific challenges on the supply (i.e., national energy mix) and the demand side (i.e., lifestyle choices). Switzerland, the geographic focus of the three papers included in this dissertation, has adopted its Energy Strategy 2050 in May 2017, laying the foundation for increasing the share of renewables and improving energy efficiency (Federal Council, 2017). In 2019, Switzerland's electricity production from renewable energy sources, including solar, geothermal, wind and biomass and excluding hydro made up 4'186 GWh of its total production (68'000 GWh) (SFOE, 2020b). The national energy law stipulates to further scale up these technologies to at least 11'400 GWh by 2035 (SFOE, 2020a). In response to the IPCC's 1.5°C report, Switzerland decided on a more ambitious long-term climate goal: reaching the net-zero target already by 2050 (Federal Council, 2021). The subsequently proposed revision of the CO<sub>2</sub> law, approved by parliament in 2020 but subject to a referendum in 2021, includes measures to decarbonize the transportation, building and industry sectors (Federal Council, 2021). To address the relatively large share of national CO<sub>2</sub> emissions (12%) stemming from air travel (FOEN et al., 2020), the current version of the CO<sub>2</sub> law also includes a tax on flight tickets and private flights (FOEN, 2020).

While halting climate change is highly dependent on effective national and global climate policies and the maturity of low-carbon technologies, the social and behavioral dimensions of change are becoming increasingly relevant (Wüstenhagen et al., 2007; Sovacool, 2009; IPCC, 2018; IRENA, 2020). In the realm of the energy sector, acceptance rates of renewable energy technologies at national levels are high (AEE, 2019; Hampl et al., 2019; Cousse et al., 2020) and public opinion is increasingly signaling the need for accelerating the energy transition (Rinscheid & Wüstenhagen, 2019; Cousse et al., 2020). However, the transition is facing some obstacles at the local level. Notably, a combination of social acceptance issues and administrative bottlenecks are slowing down onshore wind energy capacity growth rates (Bell et al., 2013; Ellis & Ferraro, 2016; Rand & Hoen, 2017; Wüstenhagen et al., 2017; IEA, 2020a). In contrast to the energy sector, the transportation sector, specifically long-haul passenger transportation, faces slightly different challenges (IRENA, 2020). As technological innovations to directly substitute air travel are not commercially available, demand reductions, particularly of intercontinental air travel, and behavior change towards train

travel<sup>2</sup> are essential to this sector's low-carbon transition (Rogelj et al., 2018; IRENA, 2020). The Swiss population acknowledges this, as 67% see consumer behavior change as an important part of solving the climate problem (Cousse et al., 2020).

The main aim of this doctoral thesis is to uncover ways to foster social acceptance and behavioral change in the electricity and transportation sectors. Specifically, the three papers included in this doctoral thesis focus on wind energy projects (*Paper 1*) and long-distance travel mode choices (*Papers 2* and *3*). These fields face complex challenges from a social and behavioral perspective and are relevant to achieving Swiss climate and energy goals (SFOE, 2020c; Federal Council, 2021). The first paper builds on prior literature focusing on the social acceptance of wind energy, which has experienced substantial growth over the past two decades (Ellis & Ferraro, 2016; Rand & Hoen, 2017; Vuichard, 2020). The second paper contributes to the travel and transportation literature, focusing on the challenge of changing frequent air travel behavioral patterns (McKercher et al., 2010; Cohen et al., 2011; Higham et al., 2016; Alcock et al., 2017). This literature stream has gained momentum in the wake of social movements such as Fridays for Future in 2018 (Fridays for Future, 2018; Higham et al., 2019; Gössling, 2019; Becken et al., 2020; Cocolas et al., 2020; Oswald & Ernst, 2020; Gössling et al., 2020). As *Papers 2* and *3* focus on travel mode choices between air and train travel, they also build on previous transportation literature focusing on behavior change away from car use towards more environmentally friendly alternatives (i.e., public transportation) (Bamberg & Schmidt, 2003; Eriksson et al., 2008; Gardner & Abraham, 2008; Thøgersen & Møller, 2008; Lind et al., 2015; Moser et al., 2018; Ralph & Brown, 2019). While all three papers are designed to include behavioral and social factors relevant to the specific empirical puzzles, they are tied together by a central notion from psychology that familiarity and experience shape perceptions, preferences and behavior (Halpern-Felsher, 2001; Hogg & Vaughn, 2018). The three papers emphasize that overcoming the status quo bias (see Samuelson & Zeckhauser, 1988) and gaining familiarity with sustainable alternatives is central to successfully achieving the climate targets. Energy and transportation policymakers and industry stakeholders (i.e., wind project developers and railway companies) can expect to gain insights into strategies that address behavioral and social challenges to implementing low-carbon solutions in these two sectors.

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<sup>2</sup> Compared to air travel, train travel can save 80-90% of CO<sub>2</sub> emissions caused by a particular travel route. To compare the CO<sub>2</sub> emissions for the same travel route by plane vs. train, see ecopassenger (2021).

## 2 Overview of the research papers

Three papers on preference formation towards climate-friendly technologies of the energy (*Paper 1*) and transportation sector (*Papers 2* and *3*) build the core of this dissertation. Table 1 provides an overview of the three research contributions included in this dissertation.

The first paper focuses on a community decision-making situation, namely the siting of wind energy projects. It adds to the literature on social acceptance of renewable energy (Wüstenhagen et al., 2007; Ellis & Ferraro, 2016; Rand & Hoen, 2017) by increasing our understanding of why noise concerns can be one of the most polarizing issues in the context of wind project siting processes (Tabi & Wüstenhagen, 2015; Rand & Hoen, 2017). To do so, *Paper 1* explores the relationship between proximity (in terms of residence) to a wind turbine and noise concerns in the context of planned wind projects. Similar to what has been done in noise annoyance literature (e.g., Haac et al., 2019), the paper additionally investigates alternative psychological and social drivers of noise concerns, namely lack of familiarity with existing wind projects and justice. The first paper's findings provide a basis to present strategies for policymakers and industry stakeholders on how to address wind turbine noise overestimations by residents during the planning phase of a wind energy project.

The second paper investigates low-carbon choices at the consumer level and focuses on mode choices between plane and train within Europe. It contributes to transportation literature focusing on the competition between high-speed rail and air transport, which finds travel time to be a crucial reason for preferring the train (see, e.g., Cascetta et al., 2011; Behrens & Pels, 2012; Sun et al., 2017). *Paper 2* adds psychological aspects of long-distance travel mode choices to this literature stream. Specifically, it explores the role of travel time perceptions and familiarity in travel mode preferences between train and air travel. As such, it also contributes to literature focusing on perceptions of travel time utility (e.g., Lyons & Urry, 2005; Jain & Lyons, 2008; Wardman & Lyons, 2016) and research streams focusing on the role of familiarity and habits in the context of daily mode choices (e.g., Verplanken et al., 1997; Kenyon & Lyons, 2003; Fujii & Kitumara, 2003; Thøgersen & Møller, 2008; Ralph & Brown, 2019). Findings are relevant to policymakers and railway operators who aim to persuade travelers to increasingly substitute air travel with the low-carbon alternative, train travel.

The third paper also focuses on consumer-level choices and psychological aspects of air and train travel preferences. Earlier studies have identified a gap between environmental attitudes and air travel behavior as a central obstacle to a low-carbon travel future (McKercher et al., 2010; Higham et al., 2016; Alcock et al., 2017). *Paper 3* provides insights on whether affective factors may help increase our understanding of long-distance travel mode choices. By focusing on the role of emotions in travel mode preferences, it addresses a research gap in the literature focusing on air travel behavior (Souche-Le Corvec & Zhao, 2020). Specifically, it (1) investigates individuals' characteristics based on their implicit affective associations with air travel, (2) explores how these implicit associations relate to air and train travel preferences and (3) compares the role of implicit associations in travel mode preferences to the role of environmental attitudes. The paper provides important insights into how policymakers and business stakeholders of the travel industry can control the spread of positive emotions related to the air travel experience while fostering positive emotions related to the train travel experience.

| Paper | Title                                                                                                                                                            | Authors                                                             | Objective                                                                                                                                                                                                                              | Method                                                                                                  | Publication status                                                                              |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| 1     | <b>How far do noise concerns travel?</b> The role of familiarity and justice in shaping noise expectations and social acceptance of planned wind energy projects | Nathalie Dällenbach <sup>a</sup> ,<br>Rolf Wüstenhagen <sup>a</sup> | Paper 1 focuses on noise concerns during the planning phase of wind projects in order to explore potential reasons (i.e., proximity, familiarity and justice) for discrepancies between expected and actual wind turbine noise levels. | Cross-sectional survey design (Study 1) & analysis of data from a public consultation process (Study 2) | Under review after 1 <sup>st</sup> R&R at <i>Energy Research and Social Science</i>             |
| 2     | <b>Low-carbon travel mode choices:</b> The role of time perceptions and familiarity                                                                              | Nathalie Dällenbach <sup>a</sup>                                    | Paper 2 investigates psychological aspects of long-distance travel mode choices within Europe. The focus lies on how travel time perceptions and familiarity with train travel affect travel mode preferences.                         | Cross-sectional survey design (Study 1) & longitudinal, experimental survey design (Study 2)            | Published in <i>Transportation Research Part D: Transport and Environment</i> in September 2020 |
| 3     | <b>How do we feel about flying?</b> Exploring the role of implicit associations with air travel in low-carbon travel mode choices                                | Nathalie Dällenbach <sup>a</sup> ,<br>Jana Plananska <sup>a</sup>   | Paper 3 explores implicit affective associations with air compared to train travel, their antecedents and their role in low-carbon mode choices for long-distance leisure travel.                                                      | Implicit Association Test (IAT) & Cross-sectional survey design                                         | Submitted to <i>Journal of Travel Research</i> in March 2021                                    |

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**Table 1** Overview of the three dissertation papers

### 3 Theoretical foundation

This section presents conceptual research contributions and theoretical insights, mainly from social psychology, on factors influencing the low-carbon energy and mobility decisions examined in this thesis.

#### 3.1 Social acceptance challenges at the community and consumer level

Social acceptance has become a central term in the study of social and psychological aspects of transitioning towards a clean energy future. One of the most cited and comprehensive definitions dates back to Wüstenhagen et al. (2007). The authors determine social acceptance of renewable energy innovation based on three dimensions: socio-political acceptance, community acceptance and market acceptance (Wüstenhagen et al., 2007). Socio-political acceptance of technologies and policies represents the most general level of acceptance at the policy level by the public and policymakers (Wüstenhagen et al., 2007). Community acceptance describes the acceptance of siting decisions of renewable infrastructure projects by residents and other local stakeholders (Wüstenhagen et al., 2007). Market acceptance encompasses consumer, investor and intra-firm acceptance (Wüstenhagen et al., 2007). While market acceptance entails decisions on small-scale renewable installations such as solar PV or consumer choices on green power products offered by electric utilities, community acceptance is the most relevant dimension for wind energy projects (Wüstenhagen et al., 2007). Although in both of these cases, individuals engage in the acceptance process of renewable energy innovations, switching to a green electricity product can be decided by a single consumer, whereas a siting decision necessitates the inclusion of various stakeholders, which is why it often becomes a political one (Wüstenhagen et al., 2007). While all three dimensions are interrelated, the socio-political dimension can lay important foundations for the other two dimensions such as changing legislations and redefining consumer choice sets (Wolsink, 2018). It is also important to note that acceptance is a process ranging from an attitude (e.g., being in favor of or opposed to a wind project) to behavior (e.g., engaging as an opponent or a proponent of a wind project) (Dethloff, 2004; Schweizer-Ries et al., 2008). Upham et al. (2015, p. 107) nicely summarize these aspects by defining social acceptance as a “positive response (including attitude, intention, behavior [...])” by individuals belonging to a social unit such as a country, community or household.

These definitions portray the multifaceted and interrelated challenges of a successful transition towards a low-carbon future. At the same time, they also highlight the importance of considering the challenges that particular technological solutions face (see Vuichard, 2020). The implementation of a technological solution may depend on a consumer or community / multi-stakeholder decision. As such, wind project siting, which is the focus of *Paper 1*, needs to consider individual preferences and multilayered processes that occur in the context of *community-level decisions* (Wüstenhagen et al., 2007). In contrast, *Papers 2* and *3* depend on *consumer-level* decisions as they focus on travel mode choices between air and train travel.

### **3.2 Status quo bias towards the most familiar option**

The transition towards low-carbon energy and mobility systems requires human beings to consider and accept alternative, more energy-efficient, sustainable options. One reason why sustaining social acceptance of low-carbon technologies can be a challenge is that, when a new alternative is introduced, individuals reveal a bias towards their most familiar option (Samuelson & Zeckhauser, 1988). Samuelson and Zeckhauser (1988) found this status quo bias to be a vital aspect of decision-making and provide three explanations for this effect. For one, a rational decision-maker will choose the status quo option if transition costs outweigh the additional utility from the alternative options or if additional benefits from switching to an alternative are uncertain. Secondly, the status quo bias may be linked to other cognitive misperceptions, including the anchoring effect (see Tversky & Kahneman, 1974), the endowment effect (see Thaler, 1980) and loss aversion (see Kahneman & Tversky, 1979; Kahneman & Tversky, 1984; Kahneman et al., 1991), whereby in the latter two cases, the status quo is used as a reference point and potential losses from switching to the alternative are perceived as larger than potential gains (Samuelson & Zeckhauser, 1988). Thirdly, psychological commitment due to sunk costs, regret avoidance, or a drive for consistency can lead to a status quo bias as well (Samuelson & Zeckhauser, 1988). Thereby, regret or guilt can result from a decision made in social settings, for example, when individuals do not conform with the dominant social norm (Samuelson & Zeckhauser, 1988).

The explanations provided by Samuelson and Zeckhauser (1988) suggest that the status quo effect applies to various decision-making situations, whereby the social and behavioral factors driving the status quo effect can vary depending on the particularities of the decision-making context. The contribution by Samuelson and Zeckhauser (1988)

also indicates that overcoming the status quo bias by transforming the low-carbon option into the familiar option is central to achieve long-term behavioral change.

### **3.3 Familiarity, other behavioral factors, social factors and low-carbon decisions**

The literature on the social acceptance of renewable energy and transportation literature provide interesting empirical insights into how familiarity with low-carbon solutions as well as other behavioral and social factors can play a role in sustaining community acceptance of wind energy projects and consumer-level travel mode choices.

#### **3.3.1 Community-level decisions on wind energy projects**

Studies on the social acceptance of wind energy show that acceptance levels tend to follow a U-shaped curve: While they tend to be highest before a specific project's announcement, they drop to the lowest levels during the planning phase, when a wind energy project becomes concrete, but rise again after construction (Wolsink, 2007). One explanation for the tendency towards low acceptance levels during the planning phase is the lack of familiarity with the impacts of wind projects (Devine-Wright, 2005). Low familiarity with wind projects may be more of an issue in countries with few wind installations, such as Switzerland, with merely 41 wind turbines (>600kW) (SuisseEole, 2020; Swisstopo & SFOE, 2021). As residents cannot draw on their own experiences, which can be essential to preference formation (Hogg & Vaughan, 2018), they may rather be influenced by interpersonal communication (Devine-Wright, 2009), the media (Songsore & Buzzelli, 2014; Songsore & Buzzelli, 2016; Holstead et al., 2017) or persuasive communication strategies of wind project activists (Barry et al., 2008). In support of the argument that familiarity can improve acceptance levels, studies have shown that residents have changed their views after construction as their fears about wind project impacts did not materialize (Warren et al., 2005; Tabi & Wüstenhagen, 2015). Also, people who live nearby (Wolsink, 2007; van der Horst, 2007; Baxter et al., 2013; AEE, 2019) or who have been close to a wind project (Cousse & Wüstenhagen, 2018) are inclined to show relatively higher acceptance levels. These research insights may partly be attributed to the role of familiarity in countering fears (Wilson & Dyke, 2016) and suggest that if people are familiar with wind projects, they may assess wind energy project risks more rationally.

Apart from familiarity, social factors play an essential role in the dynamic social and political setting of the wind project siting process at the community level (Wüstenhagen et al., 2007; Ellis & Ferraro, 2016). Justice and fairness are social psychological ideas dating back to the work of Homans (1961) and later Adams (1963). They can also influence wind project siting processes (Wüstenhagen et al., 2007; Ellis & Ferraro, 2016; Rand & Hoen, 2017). Numerous social acceptance studies suggest that a fair allocation of costs and benefits (distributional justice) and a fair wind project siting process for all involved stakeholders (procedural justice) are pre-requisites of sustaining acceptance of a wind energy project (Kuehn, 2000; Gross, 2007; Ottinger et al., 2014; Langer et al., 2016; Simkock, 2016; Scherhauser et al., 2017; Walker & Baxter, 2017a; Walker & Baxter, 2017b; Jami & Walsh, 2017; Firestone et al., 2018; Mills et al., 2019; Vuichard et al., 2019; Baxter et al. 2020). A just process and distribution of the costs and benefits can be central for a project's success even after its construction, as perceived injustice can result in higher noise annoyance levels (Hübner et al., 2019).

### **3.3.2 Consumer-level decisions on low-carbon travel mode choices**

Familiarity, habits and past behavior are central factors influencing daily (Lanzini & Khan, 2017) and long-distance travel mode choices (Bieger & Laesser, 2004). Prior studies mainly focused on how to break car use habits (Kenyon & Lyons, 2003; Fujii & Kitumara, 2003; Thøgersen & Møller, 2008; Şimşekoğlu et al., 2015; Ralph & Brown, 2019), as reducing CO<sub>2</sub> emissions from passenger road vehicles is an essential lever to reduce emissions in the transportation sector (IEA, 2020b). The attention given to air travel's growing environmental impact is more recent. Only a few studies have investigated behavioral and social determinants of long-distance travel mode choices (Sussman et al., 2020). One of the central puzzles in the extant literature is the gap between environmental attitudes and air travel behaviors (Higham et al., 2016; Alcock et al., 2017; McKercher et al., 2010). In the context of the market entry of low-cost airlines, Bieger and Laesser (2004) revealed familiarity as an important predictor of choosing a daytime train connection instead of the plane. From a behavioral viewpoint, emotions and affect can importantly guide behaviors (Loewenstein & Lerner, 2003; Peters et al. 2006; Slovic et al., 2007; Lerner et al., 2015). However, so far, they have received minimal attention from air travel behavior researchers (Souche-Le Corvec & Zhao, 2020). As for social factors, researchers are increasingly investigating social norms (e.g., Gössling et al., 2019), which can powerfully predict behavior change

(Schultz, 2007). While in the past social norms have supported frequent flying habits (Urry, 2012), global social movements (e.g., Fridays For Future, 2018; Flight Free World, 2021) pushing for more ambitious climate action since 2018, are strongly criticizing frequent flying behaviors (Gössling et al., 2019). The new dynamics have been paralleled by research focusing on whether the social norms associated with flying are changing and, in turn, could translate into behavior change away from air travel (Cousse & Wüstenhagen, 2019; Gössling et al., 2020).

## 4 Conceptual framework

The conceptual framework of this dissertation and its three research papers draws on theoretical insights outlined in the previous section (see Figure 1).

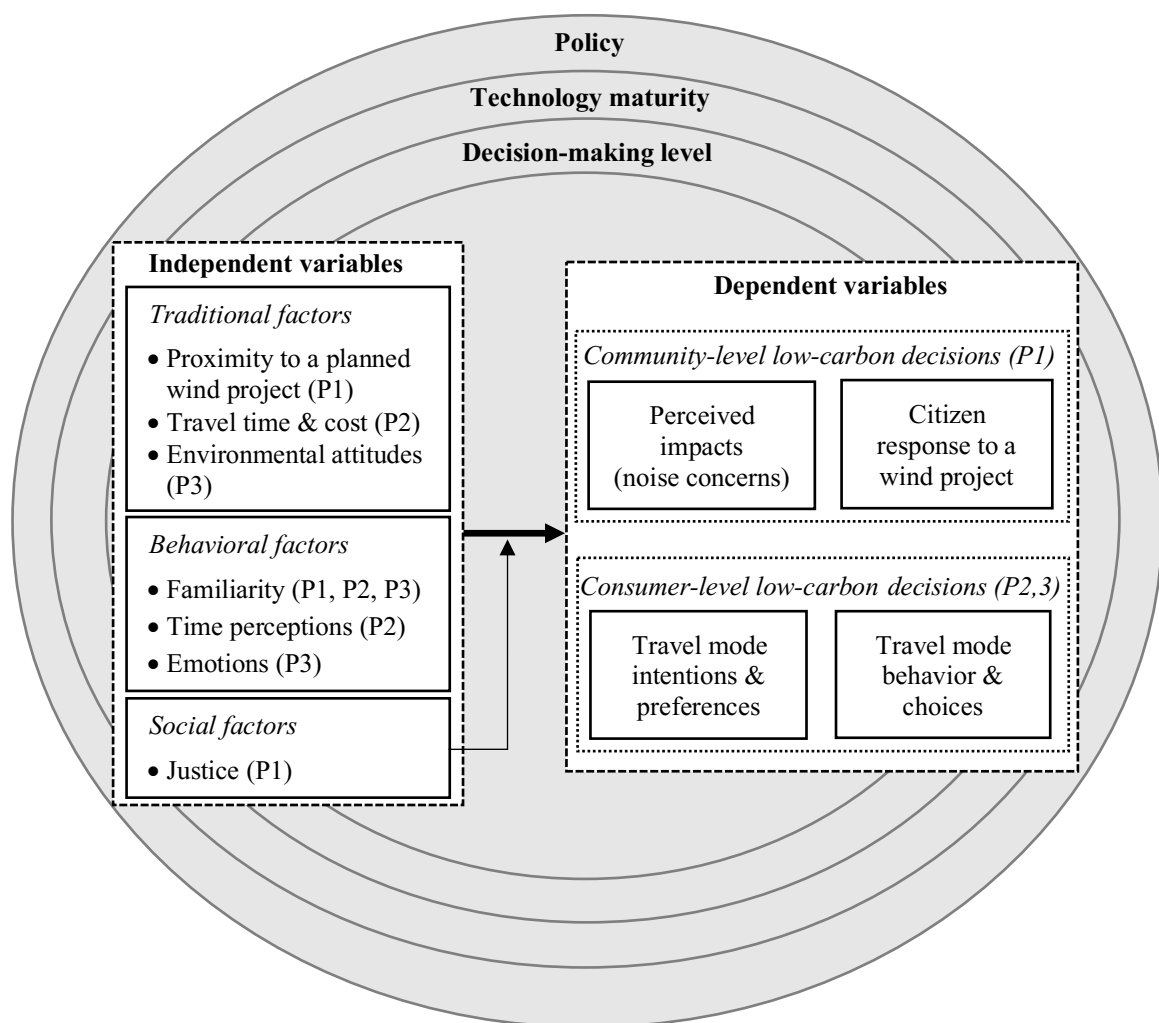


**Figure 1** Conceptual framework of the three papers (P1, P2, P3) included in this dissertation.

Firstly, the conceptual framework considers the different low-carbon choice contexts investigated in the three papers (see gray circles in Figure 1). Important aspects thereof are the *policy* context, the *maturity of low-carbon technological* alternatives and the *decision-making level*, i.e., community or consumer-level decisions.

The *policy* context is defined by the socio-political dimension of social acceptance (see Section 3.1) and sets the basic foundation for fostering the diffusion of technological innovations (Wüstenhagen et al., 2007). It can create favorable conditions for directing investments into the development and implementation of low-carbon technologies. As such, the socio-political sphere can define choice sets in different markets (Wolsink, 2018). While policies have mainly focused on decarbonizing the electricity sector in a first step, more difficult sectors to decarbonize, such as the aviation sector, are increasingly under scrutiny from policymakers and the public (IRENA, 2020; Federal Council, 2021; FOEN, 2020).

The *maturity of low-carbon technological innovations* also directly affects the available choice alternatives. In the energy sector, low-carbon technological solutions such as wind energy are available to society as they are mature and cost-competitive (Lazard, 2020). Social acceptance of wind projects remains a critical challenge to deploying this infrastructure type (*Paper 1*). In the travel sector, trains are a mature low-carbon substitute to short-haul flights. However, zero-emission aircraft, which could cover intercontinental destinations, are still far from entering the commercial market (FOCA, 2020; Wright Electric, 2020; Airbus, 2020). Thus, adopting a low-carbon technological solution is only possible for continental travel, where train travel is a low-carbon alternative to flying (see *Papers 2 and 3*). Where sustainable alternatives are unavailable, lifestyle changes become an important part of the climate solution (Rogelj et al., 2018; IRENA, 2020; see *Paper 3*). Specifically, to become carbon neutral, travelers would ideally need to change their behavior by avoiding long-haul flights, switching from air to train travel for continental destinations and offsetting those flights that cannot be avoided.

The *decision-making level*, i.e., whether a decision is taken at the *consumer-* or *community-level*, is the third important aspect that determines the context of low-carbon decision-making. As highlighted in the conceptual framework by Wüstenhagen et al. (2007), wind projects are infrastructure projects, usually subject to decisions taken at the community-level and thus require acceptance by various local stakeholders (see

*Paper 1*). In contrast, travel decisions (see *Papers 2* and *3*) come closer to consumer decisions where individuals can decide independently.

Secondly, the choice context shapes the different factors (i.e., the independent variables) relevant to a low-carbon decision. In *Paper 1*, the focus lies on community-level decisions on wind projects. The paper investigates the role of proximity to a planned wind project (*traditional factor*) in shaping wind turbine noise concerns and offers alternative explanations, including justice (*social factor*) and familiarity (*behavioral factor*). Proximity is defined as a *traditional factor*, as policymakers who have introduced minimum distance regulations in several countries, have mainly given attention to this factor, despite evidence suggesting that proximity is unrelated to wind turbine noise annoyance (Hübner et al., 2019). The central *behavioral factor* is familiarity with existing wind projects. The involvement of different local stakeholders is why the *social factor* justice is essential to wind project decisions. Not all involved stakeholders may be equally involved in the decision-making process (procedural justice) or carry the same costs or benefits (distributional justice). Thereby, *Paper 1* looks at the moderating effect of justice on the relationship between proximity and noise concerns. Familiarity is also a crucial *behavioral factor* in *Papers 2* and *3*, where the focus lies on consumer-level decisions, including continental travel decisions for which train travel is a low-carbon alternative and intercontinental air travel for which no alternative is available. Specifically, *Paper 2* investigates the role of factors in long-distance travel mode choices that have been traditionally investigated in the literature, such as travel cost and time (see e.g., Steer Davis Gleave, 2006; Small, 2012; Sun et al., 2017). However, the paper's main aim is to extend the extant literature by shedding light on the *behavioral factors*, such as the role of familiarity and travel time perceptions in low-carbon travel mode intentions and choices. Compared to *Paper 2*, *Paper 3* presents an additional *behavioral factor*. The emotional aspect of travel mode choices stands at the center of *Paper 3*, which compares the predictive validity of this behavioral factor to the one of environmental attitudes. Environmental attitudes are defined as the *traditional factor* in *Paper 3* as they build the core of prior research on air travel behavior (McKercher et al. 2010; Higham et al., 2016; Alcock et al. 2017). While travel decisions are taken at the individual level, *Paper 3* considers that emotions have a social function and can motivate people to conform with social norms (Scheff, 1988; Tangney et al., 2007; Leary, 2007).

Finally, the conceptual framework includes several dependent variables and considers that acceptance is a process during which *preferences are formed* ultimately resulting in a *low-carbon choice* (see Detlhoff, 2007; Wüstenhagen et al., 2007; Schweizer-Ries et al., 2008; Wolsink, 2018). As will be further detailed in the methodology section, *Papers 1* and *2* are based on stated and revealed data sets, thus including insights on perceptions, preferences and choices, while *Paper 3* is based on a stated preference data set and focuses on preferences.

## 5 Methodology

All three papers include a combination of stated preference data and data gathered through more in-depth methods of inquiry to account for potential biases inherent to stated preference surveys. Methodological choices for the three papers were tailored to the different research settings (see Figure 2).

*Papers 1* and *2* each comprise two complementary studies from a methodological point of view. Both papers include a first study (Study 1), based on a large, representative stated preference data set ( $N > 1000$ ) and a second study (Study 2), based on a revealed preference data set. The representative large-scale preference surveys ensure the external validity of the results. Study 2 was added to *Papers 1* and *2* to address the drawbacks of stated preference surveys, such as that intentions do not necessarily translate into action (Kroes & Sheldon, 1988; Fujii & Gärling, 2003) and survey designs may not always fully capture the realistic choice context (Hevia-Koch & Ladenburg, 2019). In both papers, results of the realistic choice settings of Study 2 confirmed the stated preference survey results. The stated and revealed preference study designs in *Papers 1* and *2* differed based on the respective research settings.

*Paper 1*, Study 1 drew on stated preference data from a large, representative Swiss sample ( $N = 1217$ ). Based on this data set, we investigated whether proximity to a planned wind project or rather familiarity with an existing wind project is linked to wind turbine noise concerns. Noise concerns were thereby measured based on whether respondents indicated that they negatively associate noise with wind turbines. For the revealed data set in Study 2, we relied on position statements submitted in the context of the public consultation process of the planned Oberegg wind project. This text data set allowed us to measure revealed preferences as we were able to assess whether citizens objected to the project based on wind turbine noise concerns. We thereby

investigated the role of proximity and justice in residents' decisions to object against the project due to noise concerns.

*Paper 2*, Study 1 also drew on a representative Swiss survey sample ( $N = 1021$ ) to measure the travel mode preferences between air and train travel and the underlying reasons for these preferences. The paper investigated the differences between likely train and air travelers, regarding the reasoning of their preferences and their familiarity with train travel (i.e., frequency of transportation use and ownership of a public transportation travel card). Study 2, a field-based intervention, investigated whether people's travel mode preferences and the reasons for these preferences hold in a realistic decision-making context. International business students from 9 European Business Schools traveling long-distance to a 2-day conference in Cologne received a monetary incentive (the intervention), namely low-carbon travel grants, if they chose to travel by train. Panel data was gathered based on two survey waves before informing students about the travel grants (wave 1) and three weeks after the 2-day conference in Cologne (wave 2). Apart from revealing real choices between air and train travel and their underlying motivations for this specific trip to Cologne, the study's experimental nature also provides insights on the causal effect of increasing one's experience with train travel on future travel intentions.

*Paper 3* introduces yet another methodological angle to this dissertation. Measuring stated preferences through self-reports as done in Study 1 of *Papers 1* and *2* can sometimes be challenging if respondents are not aware of the underlying processes of their decisions (Greenwald & Banaji, 1995) and may be subject to a social desirability bias in socially sensitive research contexts (Fisher, 1993). For this reason, researchers increasingly differentiate between measuring explicit and implicit preferences (Greenwald & Banaji, 1995; Greenwald & Banaji, 2017). Explicit measures rely on respondents' self-reports and require that respondents be fully aware of their underlying psychological processes, while implicit measures are indirect measures that aim to uncover unconscious psychological processes (Fazio & Olson, 2003; Carpenter et al., 2019). Greenwald et al. (2009) have demonstrated that implicit measures can be better predictors of behaviors than explicit measures, especially for socially sensitive research areas. As social norms about air travel seem to be evolving (Cousse et al., 2020; Gössling et al., 2020), we included an implicit measurement method, namely an implicit association test (IAT), to fully capture the antecedents of travel mode intentions for continental air travel, continental train travel and intercontinental air travel. While the

results of the IAT, which reveal implicit associations with air compared to train travel, stand at the core of *Paper 3*, we further added several explicit measures to explore the antecedents of these implicit associations with air versus train travel and their predictive validity for intended travel mode choices.

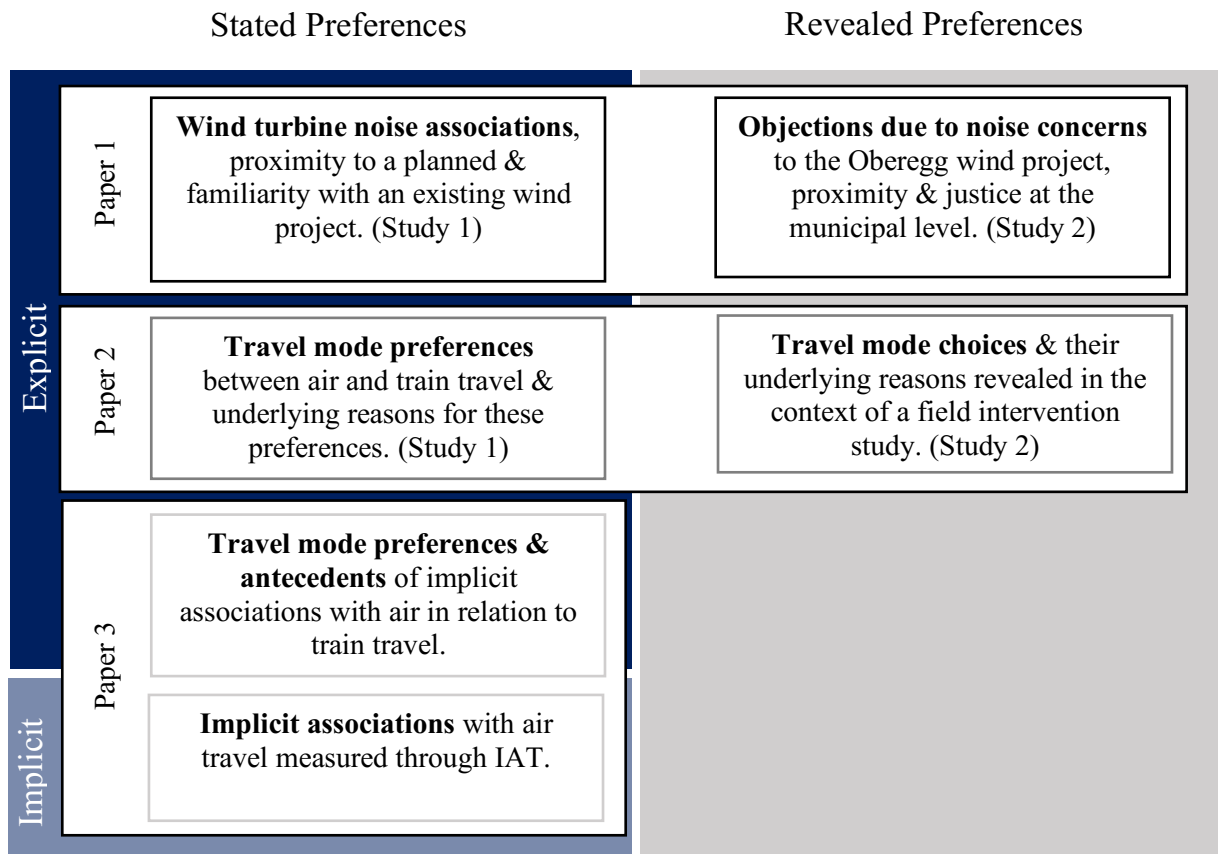


**Figure 2** Overview of methodological approaches of the three papers included in this dissertation.

## 6 Overall findings and conclusion

The electricity and transportation sectors are two of the biggest contributors to global carbon emissions. This doctoral thesis shows that apart from low-carbon policies and technological innovations, effective mitigation strategies in these sectors largely depend on overcoming behavioral and social barriers to the acceptance and adoption of climate-friendly technologies. The principal aim was to provide novel insights into preference formation at the community and consumer-level, focusing on renewable energy infrastructure and low-carbon travel solutions.

The following section outlines the dissertation's contributions to the existing literature. It then presents strategies for policymakers and industry stakeholders focusing on renewable energy deployment, specifically wind energy projects, and those

concentrating on lowering CO<sub>2</sub> emissions from long-haul transport, specifically from air travel. The insights into the behavioral and social factors that this thesis provides will result in more accurate estimations about the success of new technologies and will allow policymakers and industry stakeholders to better tailor their solutions to the preferences of the public and consumers.

## 6.1 Contributions to existing literature

This dissertation contributes to the literature stream on social acceptance of renewable energy (*Paper 1*) and transportation and travel literature (*Papers 2 and 3*).

*Paper 1* deepens the understanding of the dynamics of social acceptance during the project planning phase, focusing on wind turbine sound concerns. The main aim was to uncover how and why noise concerns unfold during a wind project's planning phase. Results of the large-scale stated preference survey (Study 1) and revealed preference data from the Oberegg wind project (Study 2) show that, except for those living closest to the wind project (< 1km), proximity does not explain noise concerns. Overall, noise concerns travel much farther than actual noise. Both studies find social and behavioral aspects as more convincing explanations of noise concerns than proximity to a planned wind project. This central finding verifies extant literature focusing on the determinants of wind turbine noise annoyance in the context of existing wind projects (Hongisto et al., 2017; Pohl et al., 2018; Radun et al., 2019; Hübner et al., 2019; Haac et al., 2019). Noise annoyance literature also suggests that subjective factors are reliable predictors of noise annoyance, while proximity to wind turbines and sound propagation are not (Firestone et al., 2015; Hongisto et al., 2017; Pohl et al., 2018; Hübner et al., 2019; Haac et al., 2019). As Study 1 finds low familiarity with existing wind projects to significantly correlate with noise concerns this also confirms previous studies suggesting that residents overestimate wind turbine impacts during the project planning phase (Wolsink, 2007; Tabi & Wüstenhagen, 2015) and those highlighting the importance of familiarity for sustaining social acceptance of wind projects (Cousse & Wüstenhagen, 2018). Study 2 points to aspects of distributional and procedural justice at the municipal level that may be driving noise concerns, factors that can also affect noise annoyance (for procedural justice see Hübner et al., 2013; Hübner et al., 2019; for distributional justice see Pohl et al., 1999; Pedersen et al., 2009; Janssen et al., 2011; Hübner et al., 2013).

*Paper 2* is one of the first contributions in transportation research focusing on the barriers to and persuaders of low-carbon long-distance travel mode choices (Sussman et

al., 2020). In addition to CO<sub>2</sub> emission-related reasons, this paper finds likely air and train travelers to systematically differ in their travel time perceptions and familiarity with train travel, based on two independent studies. Both studies confirm earlier insights on the critical role of familiarity in travel mode preferences between air and train travel (Bieger & Lässer, 2004). Study 1 shows that familiarity with public transportation translates into a higher consideration of long-distance train travel. Also, the field-based intervention study (Study 2) confirms that a trial experience (Fujii & Kitamura, 2003; Thøgersen & Møller, 2008) can result in consideration of a new travel mode alternative in the context of long-distance travel choices. Furthermore, the paper confirms previous studies suggesting that travel time should not be strictly viewed as an opportunity cost (Mokhtarian & Salomon, 2001; Lyons & Urry, 2005; Jain & Lyons, 2008; Wardman & Lyons, 2016). This conclusion is based on the finding that likely train travelers see a significantly higher value in productive travel time use than likely air travelers. Vice versa, likely air travelers find it more important to minimize their journey's total travel time than likely train travelers.

*Paper 3* introduces the affective dimension of low-carbon travel mode choices for leisure purposes into the literature stream focusing on air travel behavior and long-distance travel mode choices. 75% of respondents revealed negative or positive implicit associations with air travel. Respondents with negative implicit associations with air travel are significantly more likely to have environmentally friendly attitudes, while those with positive implicit associations find air travel significantly more exciting (compared to stressful) than those with negative implicit associations. Regression analysis shows that while implicit associations correlate significantly with continental air and train travel mode intentions, environmental attitudes do not. This fundamental result suggests that measuring implicit associations helps better understand the gap between environmental attitudes and air travel behavior highlighted by previous researchers (Barr et al., 2010; Higham et al., 2016; Alcock et al., 2017). It also confirms that emotional aspects of travel mode choices are not only important to consider for daily travel mode choices but also in the context of long-distance travel mode choices (for daily travel mode choices see Schaeffer et al., 1988; Gulian et al., 1990; Steg, 2005; Gatersleben & Uzzell, 2007; Wener & Evans, 2011; Friman et al., 2013).

## 6.2 Contributions to practice

In the current context of adaptation towards a low-carbon future, insights into citizens' preferences and behaviors are important to ensure effective policymaking and successful industry solutions. The findings of the three research papers of this thesis provide starting points for policymakers and industry stakeholders focusing on the deployment of wind projects and lowering air-travel-related CO<sub>2</sub> emissions. An overarching message for practitioners is that considering behavioral factors such as emotions and increasing familiarity with a new alternative can be an essential lever to accelerating low-carbon travel mode choices and sustaining social acceptance during a wind project's planning phase. The three paper's detailed recommendations are summarized in the following.

In the context of wind projects, *Paper 1* demonstrates that addressing concerns about wind turbine sound impacts is critical to halting the spread of noise concerns and sustaining social acceptance during the planning phase. Thereby, project developers should ideally go beyond communicating factual information. As the Oberegg wind project case study has shown, a fact-based project impact assessment may not be convincing enough to stop noise concerns from becoming widespread. Providing the population with a wind turbine experience, such as visiting wind turbines where they are up and running or simulating the experience through virtual reality (Cranmer et al., 2020), seems to be a more promising approach. It is also important to prioritize those living closest to wind turbines (< 1km to the project). They tend to be a small group but may have reasonable concerns and should be prioritized when considering the distribution of local benefits from the wind project. For this purpose, it is also vital to guarantee a fair process and distribution of benefits across political borders. Host and neighboring municipalities with residents located at the same distances to the wind project should coordinate to ensure a fair benefit-sharing scheme.

In the particular context of travel mode choices, *Papers 2* and *3* demonstrate the barriers and potential solutions to overcoming our past air travel behavioral patterns. Similar to *Paper 1*, they underscore that informing people about newly proposed alternatives (i.e., climate friendliness of train travel) may not suffice to break strong flying habits (Gardner, 2009). Climate-related behavior change will require policymakers and industry stakeholders to go beyond appealing to the population or introducing economic incentives. Allowing travelers to gain familiarity with train travel

(i.e., the new alternative) (*Paper 2*) and addressing travelers' emotional attachments to air travel (*Paper 3*) are two key aspects that policymakers and industry stakeholders should consider. The papers provide two different but potentially complementary solutions to overcoming the status quo bias towards air travel.

*Paper 2* presents two familiarity-based approaches to make respondents more prone to considering train rather than continental air travel. Study 1 shows that frequent public transportation use and the ownership of a travelcard valid beyond a specific commute (i.e., a GA<sup>3</sup> or half-fare card) is related to a higher likeliness of long-distance train travel consideration. This indication of a positive spillover effect suggests that policymakers and public transportation providers should promote public transportation use and national travelcards (i.e., a GA or half-fare card). The second approach is based on the results of Study 2, which show that the intervention was especially effective in increasing the likeliness of choosing train instead of air travel for those who are least familiar with long-distance train travel. Railway companies could introduce initiatives allowing travelers to gain long-distance train travel experience on a broader scale. Especially young travelers, who are the focus of Study 2 and have a high customer lifetime value, could be an interesting target group for railway companies (for an example see the DiscoverEU initiative by the European Union (2019)). Apart from familiarity with train travel the paper also highlights the important role of travel time perceptions in travel mode choices. Thereby, railway companies would be well-advised to highlight in their communication messages what likely train travelers see as a co-benefit of train travel, namely the productive travel time use.

*Paper 3* provides empirical evidence which shows that fostering low-carbon behavior requires considering emotional factors in travel mode choices. As advertisement and social media have promoted emotional attachments to air travel in the past (Cohen & Gössling, 2015; Gössling & Stavrindi, 2016), policymakers and industry leaders should be using these communication channels as intervention points. Communication strategies should ideally be tailored to respondents' characteristics with negative and positive implicit associations with air travel. As respondents with negative implicit associations find train travel significantly more exciting than air travel and also have more pronounced environmentally friendly attitudes and perceptions about air travel's environmental friendliness, targeting this group should entail a reminder of the

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<sup>3</sup> A GA is an unlimited travel card valid on the large majority of public transportation routes in Switzerland (SBB, 2021).

environmental unfriendliness of air travel and an emotional message underlining the excitement of train travel. Persuading the rather large share of 43% of our respondents with positive implicit associations with air travel requires a more refined approach. Compared to respondents with negative implicit associations, this group has significantly less pronounced environmentally friendly attitudes and perceptions about air travel's environmental friendliness and finds air travel significantly more exciting than train travel. To achieve behavioral change within this group, policymakers and industry stakeholders should ideally constrain the positive emotions elicited through air-travel-related media content. Specific strategies could entail the introduction of a warning about how flying endangers the health of the planet, analogous to what has been done in the context of tobacco advertising. Additionally, given the decisive influence of influencers and celebrities on the social norms of flying (Gössling, 2019), policymakers and railway companies should partner with these critical societal players. They could help promote the #flightshame movement and #flightfree pledge and, as such, contribute to halting the spread of positive associations with air travel.

## 7 Limitations and avenues for future research

The research of this doctoral thesis was carefully designed and included a variety of research methods. While the detailed limitations are highlighted in each paper, the dissertation's more general limitations and avenues for future research are outlined in the following.

First of all, the three papers' external validity is limited to the representativeness of the data sets. The stated preference data sets included in *Papers 1, 2 and 3* mirror the Swiss population. However, the research questions investigated in the context of social acceptance of wind energy (*Paper 1*) and behavior change towards low-carbon travel mode choices (*Paper 2*) are also relevant beyond the Swiss sample. Comparing the results of *Paper 1* with insights from other geographical areas that share key characteristics of the Swiss case, such as a relatively low wind energy deployment rate coupled with an ambitious national energy strategy (Swisstopo & SFOE, 2021) and a high number of planned wind projects (Pronovo, 2021), would be very interesting. Simultaneously, studying noise concerns in geographical locations where wind energy deployment is more progressed and residents are more familiar with existing wind turbines could also provide insightful results. *Papers 2 and 3* could be replicated in

neighboring countries that are comparable to Switzerland in terms of their GDP per capita and social norms associated with air travel, such as Germany or Austria. Another option could be to focus on countries where reducing air travel emissions is similarly important to achieving national climate goals due to their relatively high share of national emissions stemming from air travel, such as Luxembourg or the UK (for an overview, see Gössling & Humpe, 2020). Finally, focusing on those specific parts of the global population responsible for a relatively high share of global air travel emissions (i.e., frequent air travelers) may be necessary to reduce air travel emissions effectively.

Secondly, this dissertation demonstrates that combining studies based on stated preference data with studies based on revealed preference data allows assessing whether stated preferences hold in a real-life situation. It is however important to acknowledge that the revealed data sets were more challenging to gather, resulting in relatively small sample sizes with limited representativeness. Specifically, Study 2 in *Paper 1* focused on a wind project case study in Eastern Switzerland and Study 2 in *Paper 2* on a sample of international business students. Future researchers have the opportunity to replicate these studies (*Paper 1*, Study 2 and *Paper 2*, Study 2) on a broader scale.

Thirdly, when choosing a research design, it is imperative to consider that correlation does not automatically imply causation. While in *Paper 2*, the results of Study 1 revealed that familiarity with train travel and future intentions to travel long-distance by train correlate, Study 2 was designed as a field-intervention allowing to reveal the causal effect of the train travel experience to Cologne. However, *Papers 1* and *3* were designed to detect new patterns from which we can derive important implications but did not include any experimental elements that could reveal causal relationships. Future research may be interested in complementing the findings of *Papers 1* and *3* with experimental research designs in order to confirm whether a causal relationship underlies the correlations.

Finally, contributing to different research streams, namely research on travel mode choices and social acceptance of renewable energy infrastructure, shows that the specific research context is important when designing any piece of research. It also allowed broadening the horizon in terms of how the two streams could learn from each other to develop their methodological approaches further. In this regard, measuring implicit associations as done in *Paper 3* may be just as revealing in the context of social acceptance of renewable energies. The few studies conducted in the field of social

acceptance of energy solutions indicate that implicit associations do not always fully align with self-reports (Chassot et al., 2015; Sun et al., 2020).

Overall, this thesis, in line with recent research and reports (e.g., Rogelj et al., 2018; IRENA, 2020), highlights the importance of deepening the understanding of human behavior, including their decisions at the consumer and community-level, to successfully implement low-carbon solutions. As such, this research encourages other scholars to build on its results and develop them further in order to help accelerate the transition towards a low-carbon economy and as such achieving global climate goals.

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# Paper 1

## How far do noise concerns travel?

The role of familiarity and justice in shaping noise expectations and social acceptance of planned wind energy projects<sup>1</sup>

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### Abstract

Resistance to planned wind projects is frequently associated with expressions of noise concern. Based on two complementary studies, we investigate the underlying drivers of noise concerns. Combining a large national stated preference survey (N=1217) with an in-depth analysis of revealed preference data resulting from a public consultation process in Switzerland, we find no clear relationship between subjective noise concerns and prospective noise impacts based on residents' proximity to a planned wind project. With the exception of a high-resolution analysis of residents in the immediate surroundings (<1km) of a planned wind project, both studies seem to suggest that noise concerns travel much further than actual noise. Rather than the law of physics, (lack of) familiarity with wind energy and issues related to procedural and distributional justice appear to provide a better explanation for the geographical spread of noise concerns. Given the critical importance of social acceptance in the planning phase of wind energy projects, our studies provide important insights for policymakers. Bridging the gap between expected and actual impacts, as well as addressing misconceptions about noise among residents with low familiarity, is key. Neighboring municipalities can play a crucial role and host jurisdictions should consider appropriate measures to manage perceived justice.

**Keywords:** social acceptance, wind turbine sound, noise annoyance, proximity, familiarity, planning phase.

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# 1 Introduction

The deployment of renewable energies is key for a successful transition towards a low-carbon energy infrastructure. Installed capacity of wind energy has quadrupled over the last decade to reach 651 Gigawatts in 2019 (REN21, 2020, p. 131), one of the main reasons being the technology's cost-competitiveness (Lazard, 2020), which is set to further improve in the coming years (IRENA, 2019). In addition, public surveys show rather high acceptance rates for wind energy at a global and national level (Sposato & Hampl, 2018; Cousse & Wüstenhagen, 2019; AEE, 2019). However, at local levels and particularly in contexts where wind energy projects are close to residential areas, their implementation repeatedly faces opposition (Bell et al., 2005; Jones & Eiser, 2010; Bell et al., 2013; Ellis & Ferraro, 2016; Reusswig et al., 2016; Rand & Hoen, 2017). Across the developed world, local resistance is often associated with concerns about health effects (Songsore & Buzzelli, 2014), changes in landscape (Wolsink, 2007; Meyerhoff et al., 2010; Nadaï & Labussiere, 2017; Hallan & González, 2020) or the environment more generally (Álvarez-Farizo & Hanley, 2002; Scherhauser et al., 2017; Peri et al., 2020), as well as issues of distributional and procedural justice (Gross, 2007; Simcock, 2016; Walker & Baxter, 2017). Strong and vocal opposition, as well as legal action, repeatedly result in wind energy projects being delayed or abandoned (Wüstenhagen et al., 2017).

Previous literature on social acceptance has assessed public perceptions of wind turbine impacts (Wolsink, 2007; Walker et al., 2014). The results of these studies are essential, as the public's risk perceptions determine policy preferences (Stoutenborough, et al., 2013; Walker et al., 2018; Mayer, 2019). However, most of these studies have been conducted in the context of existing wind projects. In contrast, only limited attention has been devoted to empirically investigating residents' concerns during the planning phase, which constitutes a critical bottleneck for sustaining social acceptance (Pohl et al., 2018; Mills et al., 2019). During the planning phase, residents form expectations about wind turbine emissions, which will shape their opinion about whether a wind project should be built or not and have also been shown to influence actual noise annoyance after turbines have been built (Hübner et al., 2019).

In this paper, we focus on the planning phase and investigate the geographical distribution of noise concerns in order to explore potential reasons for discrepancies between expected and actual noise levels. Knowing more about opposition due to noise

concerns is vital since noise is one of the most polarizing issues (Tabi & Wüstenhagen, 2015; Rand & Hoen, 2017) and also a key factor influencing social acceptance (Langer et al., 2017). Concretely, we investigate the relationship between proximity<sup>4</sup> to a planned wind project and concerns about prospective wind turbine noise. This is important because policymakers in several countries, despite a lack of empirical evidence (Hübner et al., 2019), have introduced minimum distance regulations, assuming that there is indeed a positive correlation between proximity and noise concerns.

From a methodological point of view, this paper comprises two complementary studies on social acceptance of planned wind projects in Switzerland. Both investigate the relationship between proximity and wind turbine noise concerns but apply different approaches and data sets. Study 1 is based on a nationwide stated preference survey (N=1217). Study 2 evaluates revealed preferences in the context of the planned wind project in Oberegg (AI), drawing on qualitative data from position statements received during a public consultation process.

This article adds to the growing body of literature on social acceptance of renewable energy (Ellis & Ferraro, 2016; Rand & Hoen, 2017). We show that in the planning phase there is no clear relationship between proximity and concerns, except for people living within 1km of the project, corroborating related literature in the operating phase which does not find such a relationship either (Hübner et al., 2019; Haac et al., 2019). In addition, we find a lack of familiarity with existing wind projects to be more powerful in explaining the geographical spread of noise concerns than proximity. These insights are essential for policymaking in terms of designing informed local decision processes. The results may also prove useful for project developers attempting to bridge the gap between expected and actual wind turbine noise.

The remainder of this paper is structured as follows. Section 2 reviews the literature on noise propagation as well as the role of noise concerns and other factors in shaping social acceptance. Sections 3 and 4 present the methods and results of the two empirical studies. In Section 5, we discuss our findings and their relevance in light of the existing literature. Section 6 concludes the paper and offers reflections on policy implications as well as opportunities for further research.

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<sup>4</sup> When discussing the geographical spread of noise concerns, the social acceptance literature typically refers to “proximity”, while more technically focused papers tend to work with the inverse construct, “distance”. As a contribution to the energy research and social science literature, we mostly use “proximity” in this paper, except in Section 2.1 where we review the technical literature on noise propagation.

## 2 Theory and hypotheses

### 2.1 Distance and wind turbine noise

From a technical point of view, wind turbine noise decreases with distance. More specifically, sound pressure levels decrease by 6 decibels (dB) for each doubling of the distance from the sound source, unless there are boundaries to reflect sound (Ver & Beranek, 2006). The relationship between distance and noise levels can vary depending on different sound types (i.e., aerodynamical and mechanical sound<sup>5</sup> (Van den Berg & van Kamp, 2017)) and the characteristics of wind projects (e.g., number of installed turbines (Pedersen et al., 2009), topography (Pedersen & Waye, 2007; Son et al., 2010), weather conditions (Blumrich, & Heimann, 2002; Forssén et al., 2010; Öhlund & Larsson, 2015; Van den Berg & van Kamp, 2017).

Because of the particularities influencing the relationship between distance and noise propagation, it is argued that setback distances<sup>6</sup> should not be exclusively distance-based<sup>7</sup> but rather sound-based<sup>8</sup> (Knopper et al., 2014). This approach is also recommended in the World Health Organization's (WHO) Environmental Noise Guidelines for the European Region, which advise an average exposure to wind turbine sound below 45dB  $L_{den}$ <sup>9</sup> (EEA, 2001; WHO, 2018). Binding regulations for wind turbine noise are generally made at national or subnational levels (Hill & Knott, 2010; Watson et al., 2012; Dalla Longa et al., 2018). Most countries apply industrial noise limits to wind turbines and have not introduced specific regulations for wind turbine sound (Davy et al., 2018). In Switzerland as well, requirements for industrial zones, as regulated in the national Swiss Noise Abatement Ordinance<sup>10</sup>, apply to wind turbines (SuisseEole,

<sup>5</sup> Aerodynamical sound is generated through inflow turbulence and trailing edge sound (Van den Berg & van Kamp, 2017). Trailing edge sound is heard best outside, close to wind turbines, inflow turbulence noise is the relatively more dominant sound at larger distances and indoors (Van den Berg & van Kamp, 2017). Mechanical sound can come from a gearbox and cause a specific pitch, which was mostly a relevant source in the case of outdated technologies (Van den Berg & van Kamp, 2017).

<sup>6</sup> Setback distance is the distance between the wind turbine and the noise receptor.

<sup>7</sup> The 10H regulation in Bavaria is an example here: This law was introduced in 2014 and regulates that the minimum distance between residential areas and wind turbines must be 10 times the total height of the planned wind turbine (Langer et al., 2016; Bunzel et al., 2019).

<sup>8</sup> A-weighted decibel levels (dB(A)) take into account human hearing sensitivities at different frequencies (Van den Berg & van Kamp, 2017).

<sup>9</sup>  $L_{den}$  refers to the day-evening-night level. Thus,  $L_{den}$  is an energy equivalent noise level ( $L_{eq}$ ) for the whole day, including penalties for nighttime noise (10dB(A) between 22.00-7.00) and for evening noise (additional penalty of 5dB(A)). (EEA, 2001)

<sup>10</sup> See Fedlex (2019).

2019a). Noise level predictions for specific wind projects have to pass an environmental impact assessment during the permitting phase (FOEN, 2011; SuisseEole, 2019a).

We derive our first hypothesis based on technological insights outlined above, suggesting that public perceptions align with the actual relationship between proximity and wind turbine noise emissions. This would imply that concerns about the physical wind turbine impacts are limited to residents living close to wind turbines, while residents living beyond the actual noise propagation radius should not be concerned about wind turbine noise. Thus, our first hypothesis reads:

*H1. The geographical spread of noise concerns aligns with the propagation of actual wind turbine noise, in that residents living in greater proximity to a planned wind project are more noise-concerned.*

## **2.2 Impacts, familiarity, and acceptance**

Contrary to our first hypothesis, behavioral research suggests that public perceptions often deviate from expert risk assessments, as the general public often lacks experience with technological risks (Slovic, 1987). Insights from social psychology indicate that familiarity with an object influences preference formation, which in turn guides behavior. As preferences become more accessible, they come to mind more readily than weak preferences (Hogg & Vaughan, 2018).

The literature on social acceptance of wind energy suggests that living next to a wind turbine (Wolsink, 2007; Van der Horst, 2007; Baxter et al., 2013; AEE, 2019) as well as having been close to one (Cousse & Wüstenhagen, 2018) tends to be positively linked to acceptance, except for a minority of residents who persistently hold negative attitudes towards wind energy (Jalali et al., 2016; Pohl et al., 2018). An important contribution by Wolsink (2007), based on a longitudinal analysis, demonstrates that actual wind project impacts tend to be overestimated during the planning, permitting, and construction phases. Thereby, attitudes follow a U-shaped curve as proposed wind projects initially show high acceptance levels but drop in their local acceptance rates during the permitting and construction phase. After commissioning, acceptance tends to rebound to higher levels, although the extent to which this is the case depends on a number of factors, including perceptions of procedural and distributional justice (Mills et al., 2019). Furthermore, van der Horst (2007) showed that 24% of respondents changed their view following a wind project's construction as expected impacts did not materialize. Regarding noise emissions, Tabi and Wüstenhagen (2015) find that Swiss

residents living near a wind project had expected noise emissions and landscape impacts to be considerably more severe than they actually turned out to be after its construction.

These research insights point to a positive relationship between familiarity with wind turbines and acceptance levels. They also highlight the crucial role of the planning phase for sustaining local acceptance. The challenge is that residents nearby a *planned* wind project may be rather unfamiliar with wind turbines, particularly those living in geographical areas with low wind energy deployment rates. Moreover, wind turbines are often sited in rural areas where other noise sources are relatively limited (Pedersen et al., 2009). As a result, in these cases, residents' risk perceptions are often not shaped by direct experience (Tabi & Wüstenhagen, 2015), familiarity (Cousse & Wüstenhagen, 2018), or knowledge (Stoutenborough & Vedlitz, 2014). Instead, interpersonal communication (Devine-Wright, 2009) and media coverage (Songsore & Buzzelli, 2014; Songsore & Buzzelli, 2016; Holstead et al., 2017) become important ways of gaining mediated experience. In fact, the discussion about the exposure to and effects of wind turbines is particularly intense prior to construction of wind projects (Deignan et al., 2013; Michaud et al., 2016b; Van Kamp & van den Berg, 2018). As such, concerns of local residents can be strongly influenced by the available information throughout the planning process<sup>11</sup>. Opponents and proponents may try to influence residents' opinions with persuasive communication strategies (Barry et al., 2008). The experimental study by Crichton et al. (2015) demonstrates the effectiveness of such communication strategies: While negative framing of information prior to wind turbine noise exposure triggered annoyance from wind turbine sound, positive information framing led to significantly lower annoyance levels, even for noise-sensitive individuals.

The preceding paragraphs indicate that physical proximity may be unable to fully explain noise concerns. Insights from risk perception research show that lack of familiarity may result in biased decision-making. Similarly, empirical findings reveal that wind project impacts are expected to be higher during the planning phase than they are actually perceived during the wind project's operational phase. Based on these theoretical and empirical insights, we hypothesize that the overestimation of noise emissions during the planning phase will translate into the geographical dimension. While actual noise levels increase with proximity, noise concerns do not.

## *H2. Lack of familiarity, rather than physical proximity, is linked to noise concerns.*

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<sup>11</sup> Average European pre-construction lead times are 4.5 years (Ceña et al., 2010), whereas in Switzerland it may take up to 10 years (Wüstenhagen et al., 2017).

## 2.3 Noise annoyance, justice, and acceptance

The social acceptance literature offers a number of compelling explanations for why perceptions of wind turbine impacts, especially with regard to noise, may differ between respondents, and how perceived impacts may influence social acceptance.

Concerning annoyance, studies investigating the impacts of existing wind projects have shown that proximity and sound levels can either not predict noise annoyance (Firestone et al., 2015; Hübner et al., 2019) or are only very weak and empirically unreliable predictors of wind turbine noise annoyance (Hongisto et al., 2017; Pohl et al., 2018). Several studies suggest that in addition to objective factors, subjective factors need to be considered when studying noise annoyance (Michaud et al., 2016a; Hongisto et al., 2017; Pohl et al., 2018; Haac et al., 2019; Hübner et al., 2019; Radun et al., 2019). These factors include attitudes towards wind turbines (Firestone et al., 2015; Pohl et al., 2018; Hübner et al., 2019), noise sensitivity (Michaud et al., 2016a; Haac et al., 2019; Hübner et al., 2019), perceived aesthetic characteristics (Firestone et al., 2015; Haac et al., 2019) as well as concerns about physical safety (Michaud et al., 2016a) and health (Radun et al., 2019). The literature on noise annoyance also points to the importance of procedural (Hübner et al., 2013; Hübner et al., 2019) and distributional justice (Pohl et al., 1999; Pedersen et al., 2009; Janssen et al., 2011; Hübner et al., 2013), which are also factors considered central to social acceptance of wind turbines (Aitken, 2010; Vuichard, 2019; Firestone et al., 2018; Hoen et al., 2019). Procedural justice focuses on the fair involvement of different stakeholders in the decision process (Kuehn, 2000; Gross, 2007; Sovacool et al., 2016). Distributional justice relates to the fair distribution of costs and benefits among involved stakeholders (Kuehn, 2000; Gross, 2007; Sovacool et al., 2016), including local residents, project developers, the communities and society as a whole (Walter, 2014).

When it comes to the link between justice and noise annoyance, previous studies have found that procedural and distributional justice can influence how the affected population perceives wind turbine impacts. As for procedural justice, studies have shown that the planning process itself can affect sound annoyance after the wind project has been built (Pohl et al., 2018; Hübner et al., 2019). Pohl et al. (2018) find that perceiving the planning phase as stressful, unfair in terms of one's own or the community's interest can be relevant factors for wind turbine noise annoyance. Results by Hübner et al. (2019) suggest that process fairness (in their European sample) and

process stress (in their US sample) are important aspects for explaining noise annoyance.

In terms of distributional justice, Songsore and Buzzelli (2014) find perceptions of injustice to be related to health risk perceptions. Other studies indicate that residents who are financial beneficiaries of a local wind project may be less likely to be annoyed by wind turbine noise than non-beneficiaries (Pohl et al., 1999; Pedersen et al., 2009; Janssen et al., 2011; Hübner et al., 2013). This could partly be due to a selection effect, where residents who decide to invest tend to have positive attitudes towards a wind project, which is less probable for residents unwilling to invest (Pohl et al., 1999; Baxter, 2017). Another possible explanation for the gap in noise annoyance between the two groups is non-beneficiaries' feeling of resentment towards beneficiaries (Pedersen et al., 2009). The underlying driver of this second explanation may either be a sense of exclusion by local networks (McDonald & Asher, 2018) or envy, a feeling of discontent aroused by another person's or group's possessions (Langer et al., 2016). This social-psychological phenomenon was previously studied by Adams (1965), who suggested that social inequity can determine behavior and cognitive processes. In the context of wind energy, Walker and Baxter (2017) have suggested that envy at the municipal level may shape the dynamics of community acceptance. Feelings of injustice may occur between inhabitants of the host municipality of a planned wind project, which benefits from the operator's tax payments, and their peers in adjacent municipalities, who are facing a comparable visual impact but cannot expect financial benefits. These dynamics may also be influenced from a procedural justice perspective if citizens of the host jurisdiction have the final say in siting decisions.

Based on these empirical and theoretical insights, we look at the moderating influence of justice on the relationship between proximity and noise concerns. We thereby focus on the municipal level and investigate differences between the host and adjacent municipalities, located at the same distance from the wind project, and expect relatively more noise concerns to originate from neighboring municipalities.

*H3. Noise concerns peak just beyond the borders of the host community.*

### 3 Study 1: Noise concerns in a stated preference context

#### 3.1 Survey and sample

Study 1 draws on a large-scale survey (N=1250) conducted in April 2019 on acceptance of low-carbon technologies and policies among the Swiss population, which focused on acceptance of wind energy projects, including questions about geographical proximity to planned and existing wind projects as well as associations that people relate to wind turbines (Cousse & Wüstenhagen, 2019; Cousse et al., 2020).

**Table 1** Study 1, Sample characteristics.

| Variables                       |                                          | Sample (N=1217)   | Swiss Population <sup>b</sup> |
|---------------------------------|------------------------------------------|-------------------|-------------------------------|
| Gender                          | Female                                   | 50%               | 51%                           |
|                                 | Male                                     | 50%               | 49%                           |
| Age                             | 15-19                                    | 6%                | 6%                            |
|                                 | 20-29                                    | 15%               | 15%                           |
|                                 | 30-44                                    | 25%               | 25%                           |
|                                 | 45-59                                    | 27%               | 27%                           |
|                                 | 60+                                      | 28 <sup>c</sup> % | 26%                           |
| Region<br>(excl. Ticino)        | Western Switzerland<br>(French-speaking) | 31%               | 25%                           |
|                                 | Alps & Prealps                           | 25%               | 24%                           |
|                                 | Swiss Plateau West                       | 20%               | 22%                           |
|                                 | Swiss Plateau East                       | 25%               | 29%                           |
| Political Attitude <sup>a</sup> | SVP                                      | 27%               | 29%                           |
|                                 | SP                                       | 21%               | 19%                           |
|                                 | FDP                                      | 17%               | 16%                           |
|                                 | CVP                                      | 12%               | 12%                           |
|                                 | BDP                                      | 4%                | 4%                            |
|                                 | GLP                                      | 6%                | 5%                            |
|                                 | Grüne                                    | 7%                | 7%                            |
| Education                       | Low/medium                               | 54%               | 56%                           |
|                                 | High                                     | 46%               | 44%                           |

<sup>a</sup> 7% of respondents indicated that they do not have a party preference.

<sup>b</sup> Information on the Swiss population is based on Swiss Federal Statistical Office (2018a) for age, gender and education; on Swiss Federal Statistical Office (2018b) for region; and on Swiss Federal Statistical Office (2019) for the distribution of political parties.

<sup>c</sup> The percentages for age, region and political attitudes do not add up to 100%, because we rounded to whole numbers.

The focus on Switzerland is interesting for several reasons. As a densely populated country, it presents an exemplary case of how the dynamics of community acceptance can affect investor interest and wind energy goals set by the national government. Furthermore, it is particularly interesting to study wind turbine noise concerns: With only 41 large wind turbines (>600kW) operating nationwide (SuisseEole, 2019b; SuisseEole, 2020), large parts of the population do not have first-hand experience with the noise impacts of the technology leaving room for perceptions being shaped by the communication of wind project developers and opponents. At the same time, in line with the goals included in the country's Energy Strategy 2050 (DETEC, 2019), more than 700 wind turbines are currently being planned (Pronovo, 2020).

After eliminating N=1 respondent due to missing values for the demographic variables resulting in a sample of N=1249, we exclude two groups of respondents from the overall sample (N=1249), resulting in a final sample of N=1217 respondents (see Table 1). Due to their very low number (N=6), we remove respondents with positive noise associations (e.g., "quiet"). We also exclude respondents who indicated they had no idea whether they are used to seeing wind turbines in their immediate environment (N=26). While we expect respondents to know whether they live near an *existing* wind project, it may be reasonable that they are unsure about living near a *planned* wind project, as the latter is not visible and at an early stage of project development, no public announcements may have been made. As such, we did not exclude people who are unsure whether they live within a 5km radius of a planned wind project from our sample. For a detailed overview of the sample funnel see Appendix A, whereby we outline the operationalization of the variables used for the analysis in Section 3.2.

## 3.2 Measures

### 3.2.1 Proximity to a planned wind project

In Study 1, the independent variable *proximity to a planned wind turbine* is operationalized based on responses to the following question: "Is a wind project planned to be built close to your home (less than 5km)?"; answer options being "yes", "no", or "I do not know". The 5km cut-off value corresponds to previous studies investigating the effect of wind turbine impacts, including sound impacts, on local acceptance (for Switzerland see Hübner et al. (2013); for Germany & Switzerland see Hübner & Pohl, (2015)). Based on their responses, we categorized respondents into three groups, namely

respondents “not nearby a planned wind project”, those living “nearby a planned wind project”, and those “unsure” about living within 5km of a planned wind project.

### **3.2.2 Familiarity with existing wind projects**

To investigate the relationship between familiarity with existing wind projects and noise concerns, we categorize respondents into groups based on their response to the following statement: “I am used to seeing wind turbines in my immediate environment.” Answer options ranged from “I fully disagree” to “I fully agree” on a 4pt. scale, and respondents had a fifth option to indicate that they “have no idea”. Respondents indicating that they agree or fully agree were labeled as living “nearby an existing wind project”, while those indicating that they disagree or fully disagree were labeled as “not nearby an existing wind project”.

### **3.2.3 Noise concerns**

The dependent variable is based on responses to the following survey question: “What are the first thoughts or images that come to mind when you think of wind energy? Please write only one thought or image per line.” We systematically coded the respective text data for answers referring to wind turbine noise emissions. Respondents’ thoughts appeared spelled out as words or short statements (e.g., “noise”; “Currently rather suspicious for reasons of noise”). We categorize respondents into two groups, the first one containing respondents without wind turbine noise associations (N=997), the second one comprising respondents with negative wind turbine noise associations (N=220).

## **3.3 Data analysis and results**

### **3.3.1 Proximity to a planned wind project and noise concerns**

To find out whether proximity to a planned wind project correlates with noise concerns, we conduct a crosstab analysis as well as a chi-square test.

The crosstab analysis gives a first indication that proximity to a planned wind project and noise concerns are unrelated. Figure 1 shows no remarkable differences in the relative frequency of noise concerns between the three groups of respondents living within, those living beyond a 5km radius, and those unsure about their proximity to a planned wind project. Concretely, 18% of the 121 respondents living within a 5km radius of a planned wind project think of noise emissions, while 82% do not. These

results are very similar for the remaining two groups: 19% of residents living beyond a 5km radius (N=797) and 15% of residents unsure about living near a planned wind project (N=299) reveal noise concerns.

A chi-square test confirms that there is no statistically significant association between *proximity to a planned wind project* and *noise concerns* ( $\chi^2(2)=1.997$ ,  $p=0.368$ ).

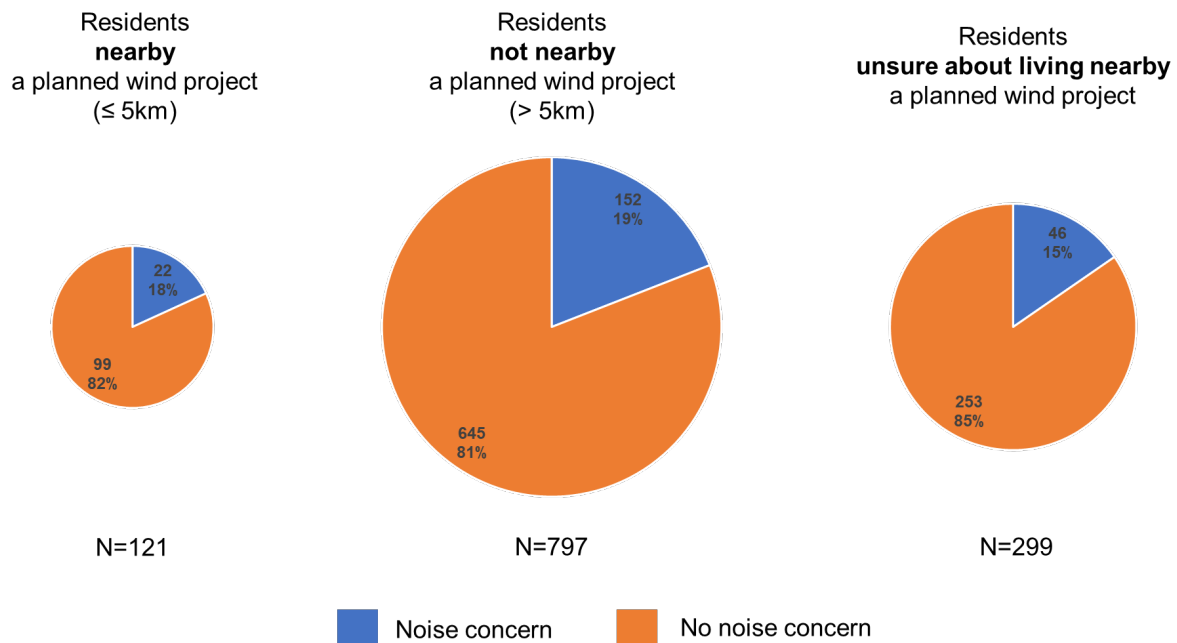


**Figure 1** Proximity to a planned wind project and noise concerns.

### 3.3.2 Familiarity and noise concerns

Next, we investigate whether residents used to seeing existing wind turbines in their immediate environment differ from those not used to seeing them in terms of noise concerns. In this case, the chi-square test reveals that residents who are familiar with wind energy are significantly less likely to mention noise concerns ( $\chi^2(2)=10.130$ ,  $p=0.001$ ). Figure 2 shows that 12% of those respondents (N=276) mention wind turbine noise. In contrast, for respondents unfamiliar with seeing wind turbines (N=941), the relative frequency of noise concerns increases to a significantly higher share of 20%.

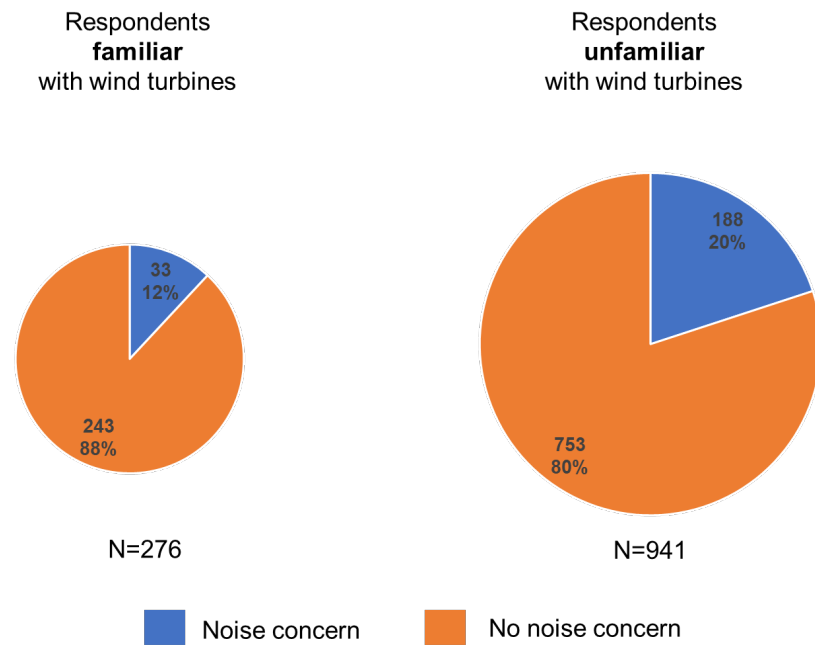


**Figure 2** Familiarity with an existing wind project and noise concerns.

### 3.3.3 Proximity, familiarity, noise concerns, and other covariates

We further conduct a multivariate analysis on the effect of proximity to a planned wind project, familiarity, and other covariates, including age (15-29, 30-44, 45-59, 60+), gender, education (high/low), language region (French-/German-speaking), political attitude on the likelihood that respondents mention wind turbine noise concerns. The binary logistic model turned out to be statistically significant ( $\chi^2(10)=39.375, p=0.000, n=1217$ ).

The results of the multivariate analysis (see Table 2) confirm that proximity to planned wind turbines, which we have entered into the model as a dummy variable, cannot explain noise concerns. In contrast, familiarity with existing wind projects has a significant effect on the dependent variable, whereby unfamiliar residents are 97% more likely to be concerned about noise.

Language region ( $p \leq 0.001$ ), age ( $p \leq 0.05$ ), and gender ( $p \leq 0.05$ ) also have a significant effect on negative noise associations. For one, French-speaking respondents are 87% more likely to indicate noise concerns than German-speaking respondents. Second, respondents in the age group of 15-44 are 37% less likely to mention noise emissions compared to respondents in the age group 60+. Third, female respondents are 39% more likely to express noise concerns than men.

**Table 2** Binary logistic model on the likelihood that respondents mention wind turbine noise concerns

| Variables                                  | B                         | SE     | Wald  | Df     | Sig. | Exp(B) | 95% C.I.<br>for EXP(B) |       |       |
|--------------------------------------------|---------------------------|--------|-------|--------|------|--------|------------------------|-------|-------|
|                                            |                           |        |       |        |      |        | Lower                  | Upper |       |
| <b>Proximity</b> to a planned wind project |                           |        |       |        |      |        |                        |       |       |
|                                            | nearby (vs. not nearby)   | -0.084 | 0.267 | 0.098  | 1    | 0.755  | 0.920                  | 0.545 | 1.554 |
|                                            | unsure (vs. not nearby)   | -0.245 | 0.190 | 1.664  | 1    | 0.197  | 0.783                  | 0.540 | 1.136 |
| <b>Familiarity</b>                         | unfamiliar (vs. familiar) | 0.676  | 0.211 | 10.293 | 1    | 0.001  | 1.967                  | 1.301 | 2.973 |
| <b>Gender</b>                              | female (vs. male)         | 0.331  | 0.154 | 4.636  | 1    | 0.031  | 1.393                  | 1.030 | 1.883 |
| <b>Region</b>                              | French- (vs. German)      | 0.624  | 0.161 | 14.925 | 1    | 0.000  | 1.866                  | 1.360 | 2.560 |
| <b>Education</b>                           | low (vs. high)            | -0.136 | 0.157 | 0.751  | 1    | 0.386  | 0.873                  | 0.642 | 1.187 |
| <b>Pol. att.</b>                           | SVP (vs. other parties)   | 0.193  | 0.168 | 1.332  | 1    | 0.249  | 1.213                  | 0.874 | 1.685 |
| <b>Age</b>                                 |                           |        |       |        |      |        |                        |       |       |
|                                            | 15-29-yearolds (vs. 60+)  | -0.468 | 0.228 | 4.208  | 1    | 0.040  | 0.626                  | 0.400 | 0.979 |
|                                            | 30-44-yearolds (vs. 60+)  | -0.363 | 0.211 | 2.954  | 1    | 0.086  | 0.696                  | 0.460 | 1.052 |
|                                            | 45-60-yearolds (vs. 60+)  | -0.116 | 0.196 | 0.351  | 1    | 0.553  | 0.890                  | 0.606 | 1.308 |
| Constant                                   |                           | -2.153 | 0.283 | 57.783 | 1    | 0.000  | 0.116                  |       |       |

## 4 Study 2: Noise concerns in a revealed preference context

### 4.1 Data and sample

Study 2 draws on qualitative data from a public consultation process<sup>12</sup> for the planned wind project Oberegg with two turbines of 4.2 MW each<sup>13</sup>, located in the Swiss canton of Appenzell Inner-Rhodes (AI). This allows us to investigate the relationship between proximity and noise concerns based on revealed preferences of individuals who engage in opposition, which is rare in the context of social acceptance of wind energy. As stated preferences do not always translate into action, it is important to differentiate between action and non-action against/in favor of a wind project (Dethloff, 2004; Schweizer-Ries et al., 2008).

<sup>12</sup> The consultation was open for a seven-week period in April/May 2018.

<sup>13</sup> See Appenzeller Wind AG (2015).

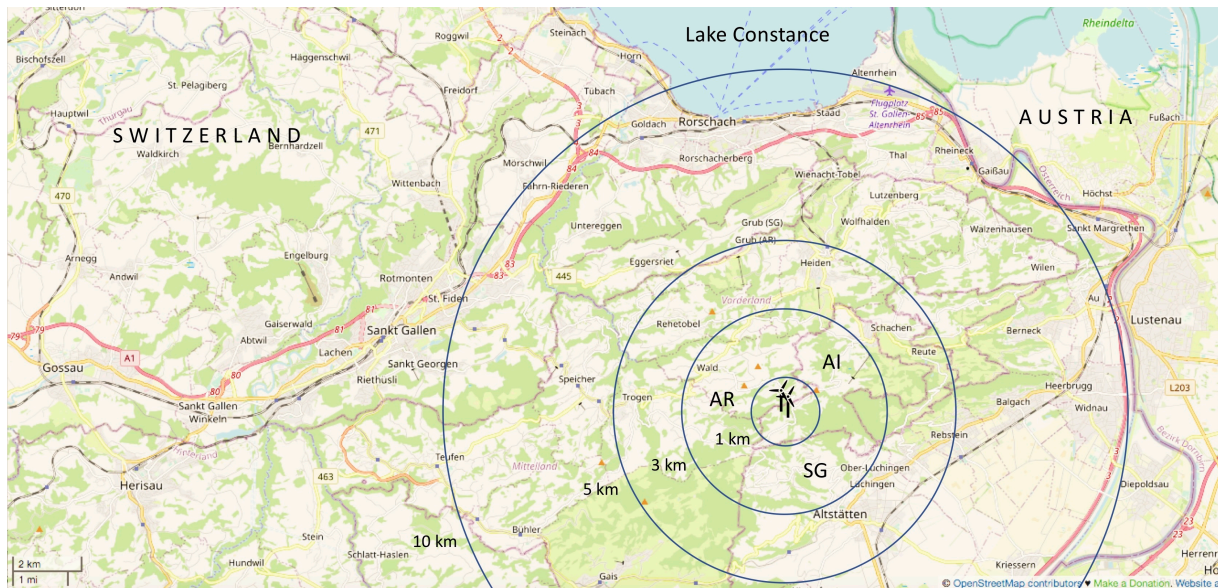


**Figure 3** Case study location in Appenzell Inner-Rhodes (AI) at the border of Appenzell Outer-Rhodes (AR) and St. Gallen (SG) (Source: own illustration based on [www.openstreetmap.org](http://www.openstreetmap.org)).

The data set at hand offers a unique opportunity to explore the relationship between proximity and noise concerns, as it includes data on objectors' place of residence, which tends to be sensitive information in the context of a public consultation process and is therefore often not publicly available. Anyone, regardless of his or her place of residence, was able to have a say in the consultation process. This is interesting from a distributional justice point of view because the project borders on two other cantons: Appenzell Outer-Rhodes (AR) and St. Gallen (SG). The center of the host municipality, Oberegg AI as well as the center of the two neighboring municipalities, Wald AR and Altstätten SG, are all approximately 3 kilometers away from the proposed wind project location. Although all three municipalities can expect to carry similar impacts, they differ with regard to the distribution of financial benefits and their influence on the decision process (cf. Section 4.2.3). Thus, we further investigate how this location at the border of three cantons impacts the level of noise concerns in neighboring municipalities.

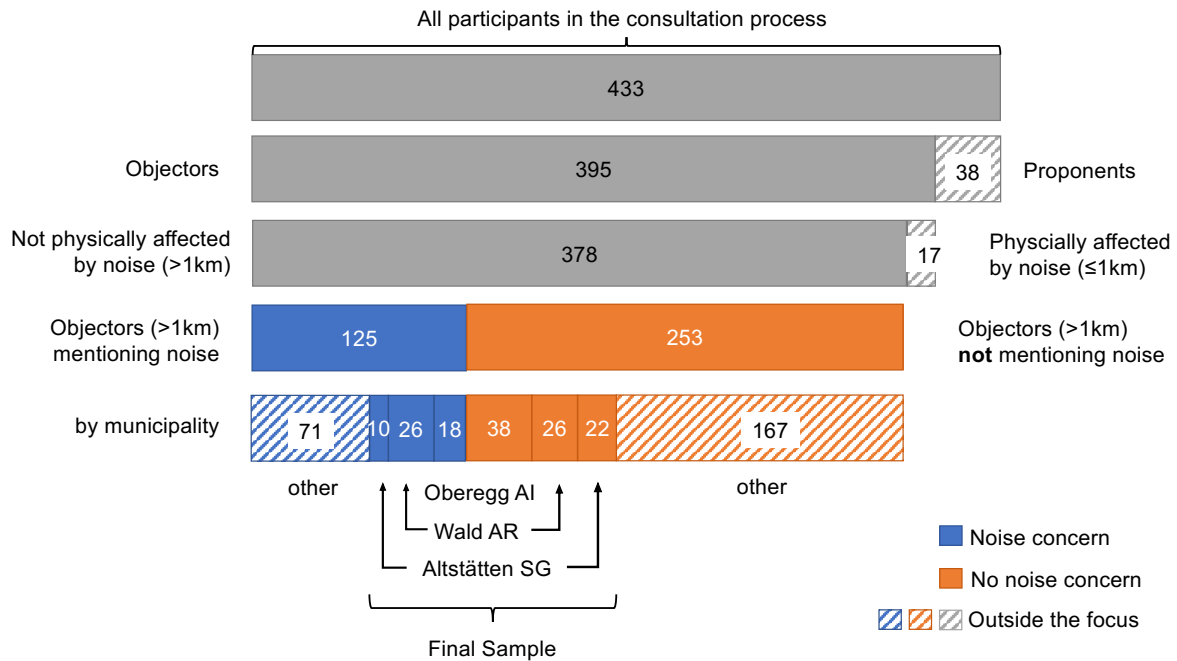


**Figure 4** Overview of sample (Study 2)

Figure 4 shows an overview of the sample of Study 2. In total, 433 individuals or households<sup>14</sup> participated in the public consultation process. Eliminating the 38 individuals or households submitting a statement in favor of the wind project leaves us with a sample of N=395 objectors against the wind project.

For our analysis of distributional justice, we are also interested in distinguishing between objectors who can expect to be physically affected by the prospective wind turbine noise and those who live further away. N=17 of the objectors live within 1 km of the planned wind project and are therefore most affected, while N=378 of the objectors live further away.

## 4.2 Method and measures

### 4.2.1 Proximity to the wind turbine

Data on place of residence from objections was publicly available at the municipal level. Street-level addresses were not disclosed in the cantonal report. Objections originated from different municipalities belonging to the host and neighboring cantons, as well as more distant locations inside and outside of Switzerland.

<sup>14</sup> We count multiple individuals living in the same household as a single vote. 32 institutions (e.g. neighboring municipalities, cantons and the Austrian State government of Vorarlberg) also participated in the consultation process, but for consistency reasons, our dataset focuses on responses by individuals or households.

We measure the distance between each respondent's residence and the planned wind project using an application based on OpenStreetMap ([www.luftlinie.org](http://www.luftlinie.org)). We operationalize the place of residence based on the location of the center of the municipality. The wind project's location is defined as the center between the two wind turbine sites (47.403000, 9.522194). We round the resulting air-line distance to full kilometers. Among all objectors, the smallest distance on municipality-level is 3km, the largest distance is 9429km. Among those mentioning noise concerns, the smallest distance is 3km, the largest distance is 460km<sup>15</sup>.

As the place of residence at municipality level is not sufficiently fine-grained to investigate noise concerns among the (most) affected part of the population, we created a higher-resolution data set of all residents living within a 1km radius of the planned wind turbines based on a publicly available phone directory ([tel.search.ch](http://tel.search.ch)). This allows us to differentiate between residents living within a 500m radius of the closest wind turbine, who are most likely to be affected by wind turbine noise (Hagemann, 2017), and those living within the 500-1000m radius. According to the project's environmental impact assessment (Hagemann, 2017), the former may hear wind turbine noise of about 40 to 45dB(A), which corresponds to the noise exposure threshold for households set by the World Health Organization (WHO) and the Swiss Federal Office for the Environment (FOEN). The latter may still hear wind turbine sound from time to time, but according to the project's environmental impact assessment will be exposed to noise levels between 35dB(A) and 40dB(A). The phone directory shows that a total of N=10 residents live within a 500m radius, and N=40 residents (including some companies and restaurants) are located within a 1km radius. For each of the people living within 1km of at least one of the two wind turbines, we measure the distance (rounded to 10 m) between their residence and the closest of the two wind turbine locations (which are 400 meters apart from each other). Subsequently, we compare this high-resolution data set to the data set from the public consultation process, allowing us to identify whether the respective residents objected against the planned wind project.

#### **4.2.2 Noise concerns**

In Study 2, we measure the dependent variable, noise concerns, based on whether individuals submitted or supported a position statement that mentions wind turbine noise

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<sup>15</sup> One respondent participating in the public consultation process resides in Rio de Janeiro (Brasil) and one in Paris (France). All other respondents reside in Switzerland, less than 200 km away from the project.

emissions as an argument to object to the planned wind project. We code for any words, sentences, or paragraphs that refer to *wind turbine noise emissions* in the text document.

#### **4.2.3 Justice at the municipal level**

We investigate the role of justice at the municipal level by comparing the number of noise concerns, both absolute and relative to population size, originating from the three municipalities located closest to the wind turbine. Specifically, we compare the host municipality Oberegg (Appenzell Inner-Rhodes) with the two neighboring municipalities Altstätten (St. Gallen) and Wald (Appenzell Outer-Rhodes), all of which are all located at approximately the same distance (3km) to the planned wind project. While the neighboring municipalities are faced with similar impacts (e.g. landscape change), only inhabitants of the host municipality can expect to benefit from the wind project's corporate tax income. Also, even though the consultation process was open to everyone, it is up to the political authorities of the host canton to decide on the implementation of a wind project (SFOE, 2020). Following our prediction (see H3), this may lead to perceived injustice by the residents of the two neighboring municipalities vis-à-vis residents of Oberegg. Thus, we expect relatively more noise concerns to originate from Wald AR and Altstätten SG than from Oberegg AI.

### **4.3 Data analysis and results**

#### **4.3.1 Proximity to the planned wind project and noise concerns**

135 out of the total 395 objectors mentioned noise concerns. Figure 5 illustrates the share of objectors mentioning noise concerns (y-axis) by the proximity to the planned wind project in kilometers (x-axis). Given that in the objection data, the residence location is provided at the municipal level, Figure 5 does not allow us to make a more fine-grained analysis of those residents living within the 3km radius (see Figure 6 for the analysis of the most affected group of residents living within 1km of the planned wind project).

Figure 5 reveals that 21% of noise objectors (29 out of 135) live at distances further away than 10km. Also, more than half (53%) of the 135 noise worries originate from distances further away than 3km. Combining this information with insights from our second data set, in which we find 10 noise objectors to live within a 1km radius, suggests that 93% (125 out of 135) of the total noise concerns were voiced by individuals for whom the prospective physical impact is likely going to be below discernible levels.

These results indicate that, while there is a tendency that noise concerns increase with proximity, wind turbine noise concerns are much more widespread geographically than their prospective physical impact.

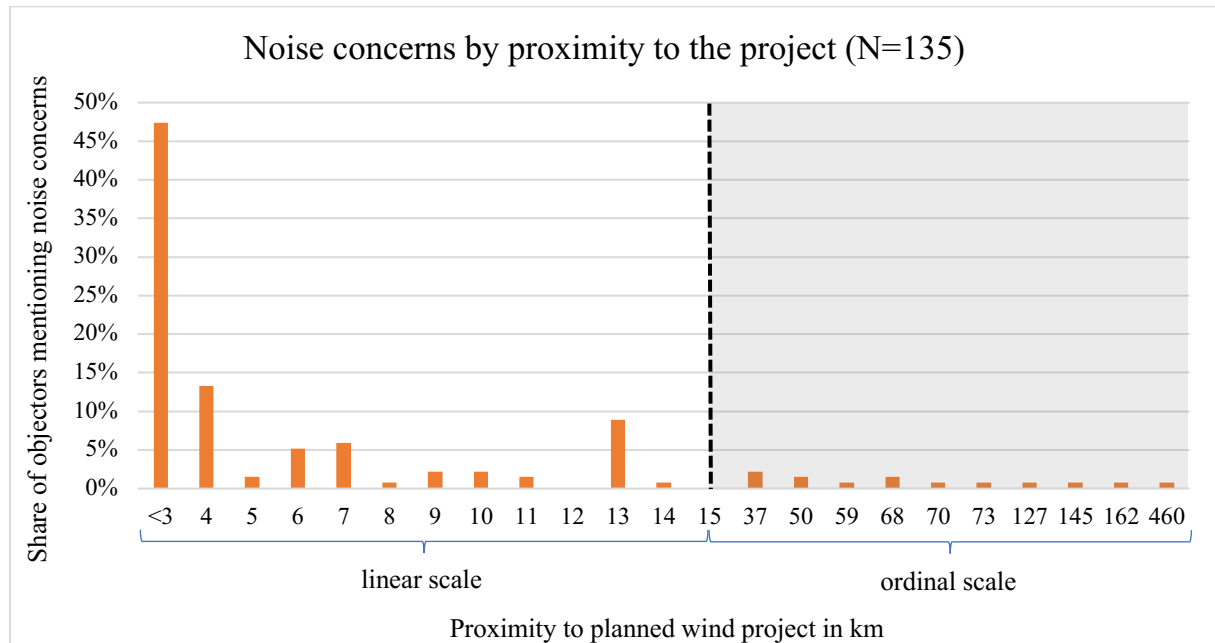


**Figure 5** Share of noise objectors in relation to the proximity (in km) to the planned wind project.

For the next finding shown in Figure 6, we have drawn on our high-resolution data set of residents living closest to the planned wind turbines (within 1km), thus focusing on the group of residents that will be (most) affected by the wind turbine emissions. The results reveal that within the 1km radius of the planned wind project, proximity does seem to matter: 10 residents live within 500m of one of the two wind turbines, where they can actually expect to hear the wind turbines. 8 out of those 10 most affected residents objected to the planned wind project, and 88% (7 out of 8) of them voiced noise concerns. This share drops to 33% (3 of the 9 objectors) for residents living between 500 and 1000 meters away (see Figure 6), where residents are less affected by the prospective wind turbine noise.

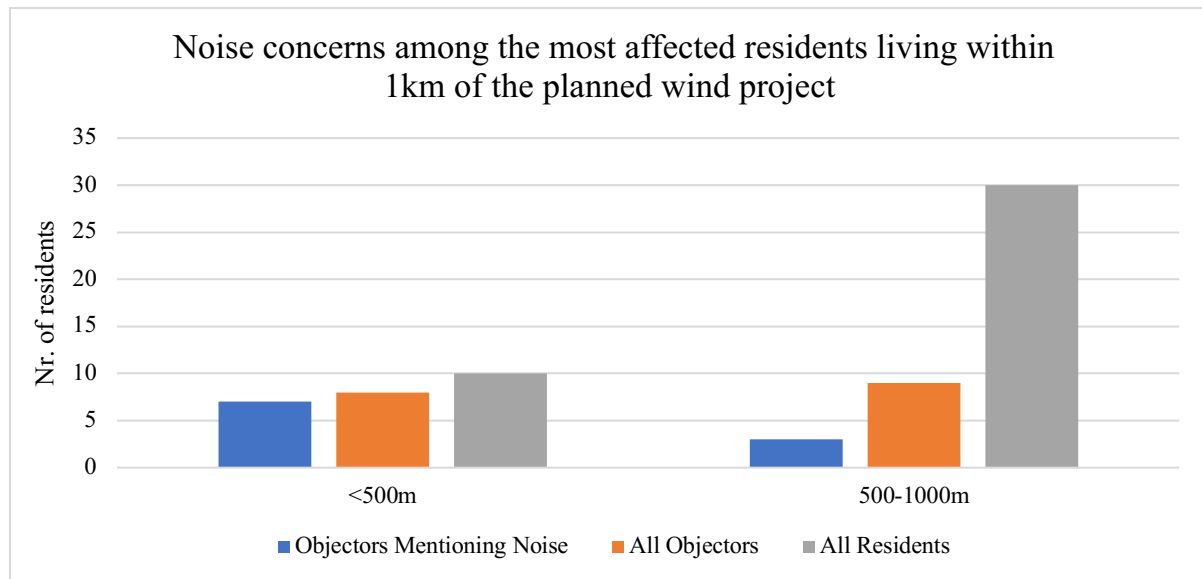


**Figure 6** All residents, all objectors, and all objectors mentioning noise concerns living within 500m vs. 500-1000m of the planned wind project.

In sum, proximity can play a role among those most affected by the planned wind turbines (see Figure 6). At the same time, when looking at the overall samples in Study 1 and 2, noise concerns can travel a lot further than the prospective impact of actual noise propagation (see Figure 5 and Study 1).

#### 4.3.2 Proximity, justice at the municipal level, and noise concerns

We now turn to the objectors living in one of the three neighboring municipalities, which are all located within the 3km radius. To explore whether justice among the three neighboring municipalities can help to understand the voiced noise concerns, we compare the number of (noise) objections among residents of Oberegg AI, Wald AR and Altstätten SG. For this analysis we focus on those objectors who live beyond a 1km radius and thus, according to the wind project's environmental impact assessment, should not expect to be significantly affected as their place of residence is likely going to be exposed to noise below 35dB(A) (Hagemann, 2017).

Figure 7 shows the 140 objectors residing in the three municipalities and >1 km away from the project.<sup>16</sup> We differentiate between objectors who raised noise concerns and those who did not. The descriptive results suggest a disproportionate share of noise concerns in one, but not the other of the two neighboring municipalities. When it comes to the share of noise concerns relative to all objections in the respective municipality,

<sup>16</sup> As described in Figure 4, N=17 objectors living within 1 km of the project are excluded from this analysis.

chi-square<sup>17</sup> tests reveal borderline significant results, indicating that objectors from Wald AR seem to be more likely to voice noise concerns compared to objectors from Oberegg AI ( $\chi^2(1)=3.561, p=0.059$ ) and Altstätten SG ( $\chi^2(1)=2.844, p=0.092$ ). Looking at noise concerns per inhabitant, the difference between Wald AR and the other two municipalities becomes more pronounced: In Wald AR 3.0% of inhabitants voiced noise concerns. This share drops to 1.0% in Oberegg AI and just 0.1% in Altstätten SG. Chi-square tests reveal that the differences between Wald AR and Oberegg AI ( $\chi^2(1)=15.658, p<0.001$ ), Wald AR and Altstätten SG ( $\chi^2(1)=242.205, p<0.001$ ) as well as between Oberegg AI and Altstätten SG ( $\chi^2(1)=60.589, p<0.001$ ) are statistically significant.

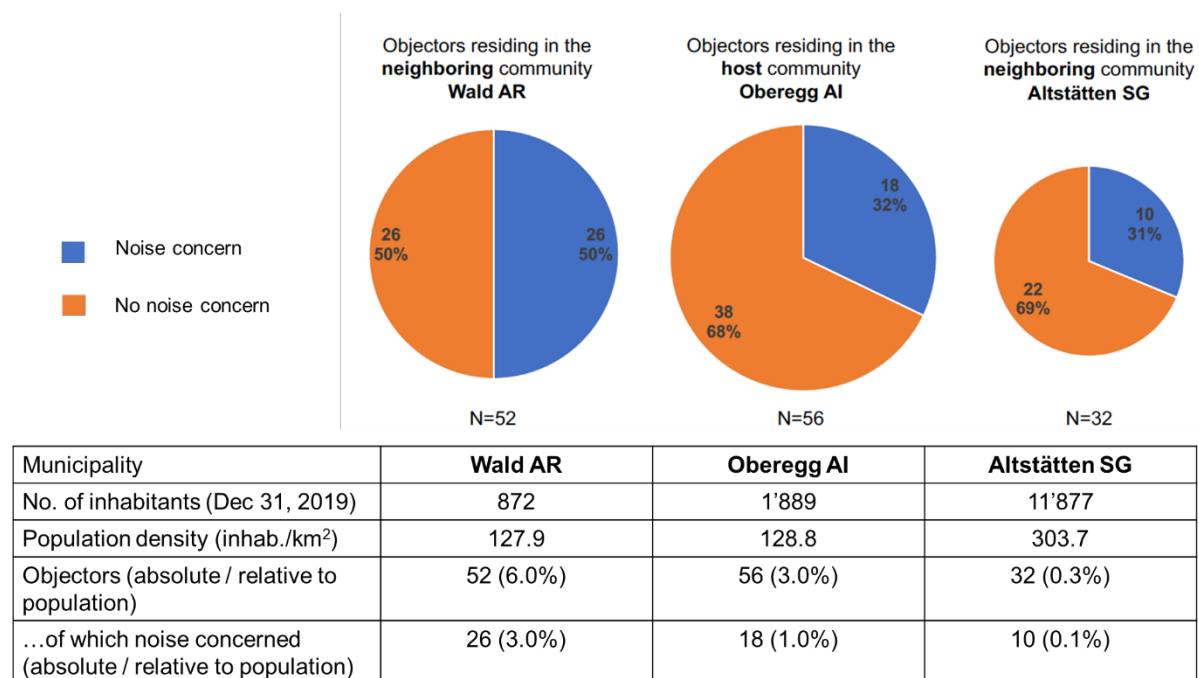


**Figure 7** Justice among municipalities and noise concerns.<sup>18</sup>

<sup>17</sup> No cell frequencies were below 5.

<sup>18</sup> Population data as of December 31, 2019, see Swiss Federal Statistical Office (2020).

## 5 Discussion

### 5.1 The relationship between proximity and noise concerns

#### 5.1.1 No relationship between proximity and noise concerns for the overall sample

The results of our representative stated preference survey (Study 1) as well as those of the overall sample of our case study (Study 2) provide initial evidence to reject H1. In Study 1, the share of respondents mentioning wind turbine noise does not differ significantly between those living within a 5km radius of a planned wind project (18% mention noise) and those living beyond a 5km radius (19% mention noise). The multivariate analysis confirms that noise concerns do not limit themselves to residents living nearby a planned wind project, but rather travel beyond a 5km radius. The analysis of the overall sample of the case study supports the finding that noise concerns travel much further than actual wind turbine noise. 93% (125 out of 135) of noise objectors live beyond a 1km radius. According to the environmental impact assessment of the planned wind project, the large majority of objectors cannot expect to be exposed to noise levels above 35dB(A), suggesting a rejection of H1<sup>19</sup>. The results for proximity support previous studies about existing wind projects suggesting that proximity and actual noise levels cannot explain noise annoyance (Firestone et al., 2015; Pohl et al., 2018; Hübner et al., 2019). Along these lines, a study conducted in the US by Haac et al. (2019) found modeled sound levels at residences in proximity to existing wind projects to be an excellent predictor of noise perception (i.e., hearing sound), but not a good predictor of noise annoyance. The latter has been more clearly linked to subjective variables (Haac et al., 2019).

#### 5.1.2 Proximity matters for the most affected

Study 2 allowed us to take a closer look at the most affected group of residents, namely those living within a 1000m radius of the closest wind turbine. Within this group, a clear majority of the objectors most affected by future noise emissions, i.e., those living within a 500m radius, mentioned noise concerns, whereas those living within 500-1000m of the planned wind project did so to a much lesser extent. Thus, within closer distances (<1000m), noise concerns seem to increase with proximity,

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<sup>19</sup> Previous research has shown that a minority of residents who live further away still report noise annoyance (Pohl et al., 2018). To address this issue, wind project developers should consider adequate noise mitigation measures such as winglets, shark fins and turbulators (ECN, 2017).

bringing residents' noise concerns in line with expert judgements of actual impacts. Given that Haac et al. (2019) found that more than two thirds of respondents were able to hear wind turbine sound levels above 40dB(A), which corresponds to the noise levels that residents within 500m of one of the two turbines can expect to be exposed to, noise concerns reflect expected noise levels. Also, the international average Community Tolerance Level (CTL) for wind turbine noise calculated by Michaud et al. (2016a) based on six field studies indicates that the share of highly annoyed residents increases from approx. 2% at 35dB(A) to approx. 4% at 40dB(A) and approx. 10 % at 45dB(A) levels. In their dose-response analysis Haac et al. (2019) find comparable results. Thus, those living within 500m of one of the two wind turbines cannot only expect to hear wind turbines but based on the CTL by Michaud et al. (2016a) are also more likely to be annoyed by the noise. As such, a potential explanation for the contrasts in our findings between the overall sample and the high-resolution sample of Study 2 could be that residents who expect to be the most affected by the turbines are better informed about the planned wind project's impacts than less affected residents.

In sum, our findings on the relationship between proximity and noise concerns suggest, that we need to differentiate between those residents living closest to the wind turbines and the less affected, more general populations (i.e., the sample of objectors living >1 km away in Study 2 and the nationwide sample in Study 1).

## 5.2 The role of familiarity

In contrast to proximity to a planned wind project, we find significant results for the variable familiarity with existing wind projects, for the nationally representative sample in Study 1: People used to seeing wind turbines in their immediate environment were significantly less likely to mention wind turbine noise worries. Thus, lack of familiarity seems to be a good explanation for why people think about noise emissions. These insights support the theoretical prediction of H2.

The multivariate analysis also points to differences between the French- and German-speaking parts of Switzerland. This difference may be connected to the current exposure of these regions to planned wind projects<sup>20</sup>. Residents nearby planned wind projects are most exposed to ongoing debates about potential wind turbine impacts

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<sup>20</sup> While there is no official database of planned wind projects, there have been attempts to map the projects that are in the pipeline, showing the higher number of planned wind projects in the French-speaking part of Switzerland, see Stiftung Landschaftsschutz Schweiz (n.d.).

including noise emissions (Barry et al., 2008; Michaud et al., 2016b, p. 1477; Van Kamp & van den Berg, 2018; cf. Section 2.2). With increasing direct exposure to planned projects, the general public may perceive both the negative noise concerns and the objective information about the actual noise level more strongly (i.e., information and disinformation will be balanced). Exposure to media reports or local debates can influence what comes to people's minds when thinking of wind projects and may partly explain the difference between French- and German-speaking residents.

This second main finding of Study 1, namely that familiarity with wind turbines will lower the likeliness of negatively associating wind turbines with noise, supports earlier studies focusing on social acceptance, which suggest that individuals overestimate wind turbine impacts prior to the commissioning of a wind project (Wolsink, 2007; Tabi & Wüstenhagen, 2015) or if they lack familiarity (Cousse & Wüstenhagen, 2018). As noise annoyance studies focus on the operational phase of wind projects, and thus residents in these study samples tend to be familiar with wind turbines, we cannot directly compare our results on noise concerns. However, our finding does parallel with those of noise annoyance studies in that subjective factors seem to be more important than objective factors (see e.g., Haac et al., 2019).

### **5.3 The role of justice**

Our third hypothesis predicted noise concerns to peak just beyond the borders of the host community. In contrast, in Study 2 we find that the share of noise concerns is higher in one (Wald AR), but not the other of the two neighboring municipalities (Altstätten SG) compared to the host community (Oberegg AI) itself. Thus, we cannot confirm H3. There are several potential reasons for the comparatively larger number of (noise) objections from Wald AR. For one, a key spokesperson of the opposition group, "Pro Landschaft AI/AR", resides in Wald AR. Secondly, small municipalities like Wald AR might be more susceptible to collective opinion swings than larger ones such as Altstätten SG. Thirdly, Appenzell Inner-Rhodes and Appenzell Outer-Rhodes used to be part of the same jurisdiction before splitting up along religious lines in mediaeval times, leading to a degree of historic rivalry. Such longstanding intergroup relations have been shown to influence social acceptance (Batel & Pataco, 2020). Finally, residents of less urbanized municipalities such as Wald AR may be more sensitive to noise emissions (see e.g., Pedersen & Waye, 2007), which may explain why less noise concerns originate from Altstätten SG. Although the results on the role of justice are

somewhat conflicting, the difference between Wald AR and Oberegg AI does insinuate that taking procedural and distributional justice at the municipality level into account may be critical to the success of a wind project.

## **6 Conclusions, implications, and further research**

This article adds to the literature on social acceptance of wind projects by studying noise concerns during the planning phase, which poses the most challenging project phase for sustaining the acceptance of wind projects (Wolsink, 2007). Our central aim was to investigate whether residents living near a planned wind turbine are more likely to be concerned about wind turbine noise than those living further away. We have also explored alternative explanations for a potential discrepancy between expected and actual noise levels. Prior studies have found noise to be a central issue driving opposition against wind projects (Tabi & Wüstenhagen, 2015; Rand & Hoen, 2017), yet insights on the dynamics of opposition in the planning phase are rare. Our findings may build a basis for policymakers to design local wind project siting decisions and for project leaders to come up with strategies to address noise concerns.

### **6.1 Conclusions and implications for policy and practice**

First, our findings in both studies show that outside the immediate vicinity (less than 1km) of a project there is no clear correlation between proximity to a planned wind project and noise concerns, suggesting that noise concerns travel further than actual noise. More specifically, Study 1 has shown that residents living within a 5km radius of a planned wind project are not more likely to have noise associations than residents living further away. Similarly, in Study 2, we have found noise concerns to spread far beyond the prospective impact of actual noise propagation. 93% of all noise concerns voiced in a public consultation process originated from individuals living in distances from the planned wind project from which they cannot expect to hear wind turbine noise (>1km from the planned wind project). 21% of noise objectors even live much further away (>10km from the planned wind project).

At the same time, our study demonstrates the value of taking a closer look. Creating a high-resolution data set of the most affected population around a planned wind project, we find that among residents living within 1km of the project, there is a significant difference between those living within a 500m radius (and are therefore likely to be

exposed to noise of 40-45 dB(A)) and those living between 500m and 1km distance (more likely to be exposed to noise of 35-40 dB(A)). 88% (7 out of 8) of the closest objectors express noise concerns, while that is the case for only 33% of the slightly more remote neighbors opposing the wind project.

The challenge for project developers, therefore, is twofold: Addressing the plausible noise concerns of the closest neighbors, even if they are limited in numbers, should be a key priority. On the other hand, convincing those living further away, who may be unaware that they are unlikely to be affected by discernible levels of turbine noise, is an equally important task that is moderated by dynamic processes of (inter-)group communications.

The former challenge may be addressed by assuring distributional justice, including legislation about local benefit-sharing. In cases like the one we investigated in Study 2, where expected impacts cross political boundaries, this may create additional challenges. Especially in countries with fine-grained legislative structures, such as Switzerland, this might be supported by some degree of inter-regional compensation.

As for the latter challenge, namely closing the gap between noise concerns and expert judgments about wind turbine noise, policymakers, and project developers may draw on the findings of Study 1 showing that residents familiar with wind turbines are less likely to be concerned about wind turbine noise. Increasing familiarity, either through organizing excursions for residents to visit existing wind turbines in other regions or by creating simulations or virtual reality experiments (Cranmer et al., 2020), may be a promising avenue to address noise concerns.

Finally, it is important to be aware that noise concerns do not spread in a vacuum. Perceptions matter and apart from being informed or uninformed, residents of local communities will also be exposed to deliberate efforts aimed at shaping noise perceptions, sometimes based on emotionally powerful, yet inaccurate metaphors. In the specific context of Study 2, the opponents repeatedly claimed that wind turbines were “loud as a chain saw” (ProLandschaft AR/AI, 2017), whereas the official environmental impact assessment suggested the vast majority of residents would be exposed to sound levels of less than 40 dB(A), which is similar to sound levels experienced in a library. In such contested environments, persuasive communication efforts early in the process to prevent the spread of misinformation and fear are key to ensure evidence-based decision making.

## 6.2 Limitations and further research

In designing our research, we carefully tried to balance the strengths and weaknesses of complementary research methods. Being mindful of the limitations inherent in each of the studies provides relevant starting points for further research. Study 1 allowed us to draw on a large, national sample, but working with stated preference data inherently leads to a degree of hypothetical bias. The majority of our respondents indicated that they actually do not live within 5km of a currently planned wind project, which is natural given that wind projects tend to be sited away from major population centers, but may limit respondents' ability to accurately predict noise concerns that might arise once they are actually exposed to a real project nearby (including active communication by opponents). Future research working with large national samples could conduct a randomized controlled trial where some respondents are exposed to information prompting the salience of noise concerns to see whether differences arise. Another limitation of Study 1, similar to much of the extant social acceptance literature, is that defining proximity as living within a 5km radius of a planned project may miss some of the important nuances that occur among the most affected population. To address this concern in Study 2, we engaged in a unique high-resolution analysis of noise concerns among the strongly affected population within the 500m and 1km radius around a planned wind project. Although this comes at the expense of smaller sample size and leads to an exponential increase in data collection effort, zooming in to such level of detail provides new insights about processes of social acceptance and highlights the key role of a small number of salient stakeholders in making or breaking a project. Further research may try to replicate such fine-grained local analysis in different settings, including comparisons over time to discern some of the dynamic processes of local acceptance.

Furthermore, in both of our studies we used distance as a proxy for actual sound levels. This proved to be valuable as we were interested in noise concerns in a context where wind turbine sound is not yet existent. It is, however, important to consider that, in addition to distance, actual sound propagation also depends on factors including ground cover (Barlas et al., 2017), meteorological conditions (Blumrich, & Heimann, 2002; Forssén et al., 2010; Öhlund & Larsson, 2015), prevailing winds (Katinas et al., 2016; Iannace et al., 2019), background sounds (Katinas et al., 2016), topography (Pedersen & Waye, 2007; Son et al., 2010) and obstructions (Son et al., 2010). While in

Study 1 we were not able account for these additional factors, in Study 2, we were able to relate our distance proxy to the noise models of the Oberegg wind project's environmental impact assessment (Hagemann, 2017). Even more reliable than a model of noise propagation would of course be actual measurements after implementation of the project. Future research adopting a longitudinal design could compare noise concerns in the planning context with actual impacts during the operation phase. Such a research design would provide a novel connection between our work and previous research investigating actual noise annoyance among residents near existing wind projects (e.g., Haac et al., 2019).

Finally, we focused on a unique project setting in Study 2 where a wind project was planned close to three municipalities belonging to different jurisdictions (cantons). While our third hypothesis predicted a peak in noise concerns right outside a host community's borders due to distributional justice issues, this seemed to hold true for one but not the other of the two neighboring communities, which raises interesting questions for further research. How do factors like the communication tactics and local origin of key proponents and opponents, as well as historic intergroup conflicts, influence processes of social acceptance? And do noise concerns indeed spread differently within large and small municipalities as our case study seems to suggest? Further research replicating our study in different geographical settings, potentially also spanning national borders, could shed light on these important questions.

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## 8 Appendix

### Appendix A Study 1, sample funnel

|                                                                                                                                    |             |       |
|------------------------------------------------------------------------------------------------------------------------------------|-------------|-------|
| <b>Original sample</b>                                                                                                             | <b>1249</b> | 100%  |
| - Respondents with <i>no</i> noise associations                                                                                    | 1021        |       |
| - Respondents with noise associations                                                                                              | 228         |       |
| ○ Negative noise associations                                                                                                      | 222         |       |
| ○ Positive noise associations                                                                                                      | 6           |       |
| <b>Reduced sample excl. pos. noise associations</b>                                                                                | <b>1243</b> | 99.5% |
| - Respondents <i>not</i> nearby an existing wind project                                                                           | 941         |       |
| - Respondents nearby an existing wind project                                                                                      | 276         |       |
| - Unsure                                                                                                                           | 26          |       |
| <b>Final sample excl. pos. noise associations &amp; excl. respondents unsure about living near an <i>existing</i> wind project</b> | <b>1217</b> | 97.4% |
| - Respondents <i>not</i> nearby a <i>planned</i> wind project                                                                      | 797         |       |
| - Respondents nearby a <i>planned</i> wind project                                                                                 | 121         |       |
| - Unsure                                                                                                                           | 299         |       |

## Paper 2

### Low-carbon travel mode choices:

The role of time perceptions and familiarity<sup>1</sup>

*Nathalie Dällenbach*<sup>23</sup>

### Abstract

Academic studies and recent social movements alike highlight the importance of changing flying behavior for reaching global climate goals. A particularly effective strategy for minimizing transport-related CO<sub>2</sub> emissions is to substitute flights with train travel. The same trip causes around 80-90% less CO<sub>2</sub> emissions by train than by plane. The results of this paper are based on two independent samples, the first representing the Swiss population, the second one including international business students. Both empirical studies consistently show that respondents who are familiar with train travel are also more prone to consider the train as an alternative for international, long-distance trips. Furthermore, both studies find systematic differences when it comes to travel time perceptions of likely air and train travelers: While people who are inclined to travel by plane see a high value in minimizing the total travel time of their journey, likely train travelers put less emphasis on minimizing total travel time. At the same time, prospective train travelers find it highly important to be able to use their travel time productively, which does not seem to be the case for potential air travelers. As consumer insights about the willingness to substitute flying with train travel are rare, the results of this paper build a basis for developing communication strategies and policies aiming at increasing low-carbon travel mode choices.

**Keywords:** train travel, air travel, modal choice, time perceptions, familiarity, climate change.

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# 1 Introduction

Apart from a few shock events (e.g., the 1979 oil shock, the Gulf War, 9/11 or the global financial crisis in 2008/9), there has been a continuous growth in global air traffic passenger numbers since the 1950ies (Oxley & Jain, 2015). This global trend is expected to continue, with the rise of the middle class in emerging economies (Graham & Metz, 2017). Globally, passenger flight emissions account for 2-2.5% of global CO<sub>2</sub> emissions (ATAG, 2019; REN21, 2019). While this global number may seem modest to some, passenger flight emission statistics for wealthy countries tend to change perspective. In Switzerland, a global leader in per capita flight emissions (Global Sustainable Tourism Dashboard, 2018), passenger flight emissions account for around 12-18% of national CO<sub>2</sub> emissions (WWF, 2015; Cousse & Wüstenhagen, 2019; Federal Council, 2020). Assuming the aviation sector's mitigation efforts remain less ambitious than other sectors, CO<sub>2</sub> emissions from passenger volumes could culminate in 22% of global CO<sub>2</sub> emissions by 2050 (Cames et al., 2015). The solution the world can rely on is twofold: technological innovations and behavior change towards low-carbon transport modes. Technological solutions such as the electrification of the aviation industry are on the rise (Roland Berger, 2017). Yet, it may take at least another decade before electric planes are ready for the commercial market (see, e.g., Kolirin, 2018). Also, historically, emissions growth from increasing passenger flight numbers has outpaced technological efficiency gains (Peeters et al., 2016). Thus, behavior change is central, but may be contingent on relative price increases of plane tickets and changing social norms. In the past one to two decades, low-cost carriers have been responsible for a large part of growth in air travel demand (Rey et al., 2011; Abda et al., 2012; Dobruszkes & Mondou, 2013; Tsui, 2017). Current political discussions in several countries (e.g., Switzerland and Germany) on the introduction of CO<sub>2</sub> taxes on flight tickets aim at increasing flight relatively to train ticket prices. As for changing social norms, two diverging tendencies are observable. Frequent flyer and hypermobile lifestyles (Shaw & Thomas, 2006; Becken, 2009; Cohen & Gössling, 2015; Cohen et al., 2018) accelerate air travel growth. Contrarily, the "flying shame" movement (e.g., #flygskam) has led to decreasing flight passenger numbers in Sweden since 2017 (Hoikkala & Magnussen, 2019). In addition, a study by the Worldwide Fund For Nature shows that, in 2018, 18% of Swedes chose train over air travel (Hoikkala & Magnussen, 2019). Substituting flights with train travel

can significantly reduce transport-related CO<sub>2</sub> emissions as a train trip can save around 80-90% of CO<sub>2</sub> emissions compared to the same trip with a flight<sup>4</sup>.

In addition to the Swedish example, several academic studies (e.g., Hares et al., 2010; Cohen et al., 2011) highlight the importance of investigating to what extent changing behavior towards low-carbon substitutes is a possible solution to limit CO<sub>2</sub> emissions from air travel.

While past research shows that a shift from air to high-speed rail travel is possible (e.g., Albalade et al., 2015; Gundelfinger-Casar & Coto-Millán, 2017), studies that shed light on the role of social and psychological aspects of behavior change towards international railway travel are relatively limited. This paper contributes to this research gap by addressing the following research questions:

RQ1. To what extent do consumers consider train trips as a viable alternative to flights?

RQ2. How do time perceptions affect travel mode preferences?

RQ3. How does familiarity with train travel affect travel mode preferences?

Methodologically, this paper draws on two different primary data sets from two complementary studies to better comprehend the drivers of low-carbon travel mode choices. Both studies rely on highly relevant samples for the research at hand as they consist of frequent, international travelers.

Study 1 is based on a representative survey (N=1021). Study 2 consists of a field-based intervention study, including data on stated and revealed preferences from an independent sample of international business students (N=50). Thereby, in both studies, respondents were asked about their preferences for substituting air with long-distance train travel for distances of 300km or longer<sup>5</sup>. As such, both studies differentiate between two main groups: likely train travelers and likely air travelers. The former consider the train to be a viable option compared to the flight, whereas the latter are

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<sup>4</sup> In some cases, the train saves even more emissions compared to the flight. See, for example, Zurich-Paris on <http://ecopassenger.org>. While CO<sub>2</sub> emissions per passenger kilometer can vary (e.g., due to a country's electricity mix), the ongoing decarbonization of electricity systems will allow for very low CO<sub>2</sub> emissions per passenger kilometer to apply more generally (Sims et al., 2014). To date, three-quarters of passenger rail transportation is electrified (IEA, 2019).

<sup>5</sup> This long-distance train travel definition would correspond to approx. a 1 to 1 hour 15 minutes flight: A 300km railway distance such as Zurich-Frankfurt (308km in terms of air distance) would equate with a 1-hour flight. A somewhat longer railway route in terms of km would be Zurich-Paris (489km in terms of air distance), which would correspond to a 1h 15 min flight. (Source for train travel routes in km: [www.luftlinie.org](http://www.luftlinie.org)).

unlikely to do so. In Study 1, train travel consideration applies to a hypothetical setting, while in Study 2, to a real-life decision-making context.

Based on results from the two studies, practical implications will be proposed, both for railway operators looking for ways to increase their customer base, as well as for policymakers to foster behavior change towards low-carbon travel options. From an academic point of view, this paper contributes to the literature on the barriers to and persuaders of sustainable long-distance travel mode choices and behavior change. Sussman et al. (2020) identify this to be a key gap in the literature on behavioral aspects of modal choice.

In the following, Section 2 builds on relevant literature on the drivers of international, long-distance travel mode choices to formulate hypotheses. Section 3 presents the data, methods and results of the large-scale survey. The content of Section 4 focuses on the data, methods and results of the intervention study that investigated real travel behavior in a longitudinal setting. Section 5 discusses the overall results and relates them back to extant literature. Section 6 concludes this paper with main insights and derives implications for policymaking and railway operators.

## **2 Literature review and hypotheses**

### **2.1 Modal choice: plane vs. train**

One central literature stream for understanding why people choose the train over the plane focuses on the substitution effect of high-speed rail on air transport. Within this particular research field, several studies find travel time to be the most important criterion for choosing the train over other alternative travel modes (Steer Davis Gleave, 2006; European Commission, 2010; Cascetta et al., 2011; Behrens & Pels, 2012; Sun et al., 2017). Further aspects that are often found to be a relative advantage of high-speed rail are service frequency and access time (Bieger & Laesser, 2001; Behrens and Pels, 2012). Some studies such as the one by Bieger and Laesser (2004) look into a broad number of possible attributes as drivers of choice between train travel and flying. More specifically, Bieger and Laesser (2004) discover that the most important determinants of modal choices, in the context of the market entry of low-cost airlines in Switzerland, are travel time, flexibility, comfort, travel cost and safety. Thereby, the preference for air travel, in general, is driven by perceived travel time and comfort (Bieger & Laesser, 2004). Low-cost airline offers are found to be a good option for time-sensitive travelers,

under the condition that these offers include short transfer times and convenient inter-modal exchange (Bieger & Laesser, 2004). Costs, familiarity<sup>6</sup> and sustainable behavior determine the preference for the train (Bieger & Laesser, 2004).

## **2.2 Travel time perceptions**

### **2.2.1 Perceptions of travel time: productive travel time vs. total travel time**

Cost-benefit analysis is a common approach to transport policy design. As pointed out by Mokhtarian and Salomon (2001), Lyons and Urry (2005) and Jain and Lyons (2008), these analyses (e.g., Mackie et al., 2001) mainly assume time to be an opportunity cost of a trip and are based on the rationale that travel time is unproductive. To some extent, these models acknowledge that travel time can be used for work purposes (Fowkes, 2001). Contrarily, Jain and Lyons (2008) propose that travel time may have an intrinsic value and diverges from the mere monetary assessment of time as cost. The authors highlight that subjective experiences and context influence perceived travel time utility (Jain & Lyons, 2008). Also, Lyons and Urry (2005) suggest that travel time can be productive and may lead to a rethinking of traditional appraisal methods, especially in the information age (see also Mokhtarian & Salomon, 2001; Wardman & Lyons, 2016).

A further aspect to consider is that the travel time utility also depends on the travel purpose and the travel mode. For example, in a business context traveling tends to be more time-sensitive compared to travel for leisure purposes (Mackie et al., 2001). As for the differences in travel modes, Lyons and Urry (2005) propose that travel time utility can be higher for public transportation modes as opposed to car travel. Further, LaMondia et al. (2016) suggest that automated vehicles may cause shifts in modal choices due to benefits from hands-free travel. As such, Wardman and Lyons (2016) propose that the possibilities provided by the digital age have the potential to revolutionize existing travel modes as they generally increase the benefits of travel time. While this is already the case today, Wardman and Lyons (2016) expect this trend to continue (e.g., with product innovation or the increasing flexibility of where and when business and social practices take place).

The studies above highlight that travel time perceptions will likely vary between travelers and may be one of the critical drivers for travel mode decision-making. It is

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<sup>6</sup> In this context, familiarity means that people are more familiar with daytime trains than they are with (low-cost) air travel (Bieger & Laesser, 2004).

expected that likely air travelers will find the minimization of total travel time to be more important than likely train travelers. The latter are expected to see a higher value in travel time productivity than likely air travelers.

*H1. Likely air travelers are more concerned with minimizing travel time and are less concerned about travel time productivity than likely train travelers.*

## 2.2.2 The reference point for making travel time comparisons

Considering the discrepancies between travel time perceptions, there is a need to better understand how people make comparisons between flight and train travel times. Previous research acknowledges that it is important to account for access time (i.e., time to get to and from a railway station or airport) and the quality of travel time (i.e., number of transfers) (Givoni & Dobruzskes, 2013). However, to the author's knowledge, previous studies have not looked into how people actually compare the travel time of competing travel mode options. When calculating the travel time for a given route, rational choice models would suggest that comparisons between train and air travel are made on the basis of the same departure and arrival points. In this respect, in terms of total travel time and particularly net travel time, planes tend to have a relative advantage as opposed to trains as they are often the faster mode when it comes to international, long-distance travel. In this paper, the total travel time corresponds to the door-to-door calculation of the time spent for the plane/train trip, net travel time<sub>1</sub> refers to in-vehicle travel time and net travel time<sub>2</sub> to in-vehicle plus additional retention time at airports/train stations (e.g., check-in/check-out). Productive travel time indicates the travel time used for work purposes. If one calculates air travel time on a door-to-door basis (e.g., the city center of Zurich to the city center of Paris)<sup>7</sup>, it can be similar to the total train travel time<sup>8</sup>. In addition, when traveling from Zurich to Paris, train travel time may have a higher utility thanks to a direct train connection (4h 17min) as opposed to the flight, where the net travel time<sub>1</sub> is 1h 15min and transfer and retention time result in (at least) 2h 25 minutes. One possible source of bias when calculating the actual door-to-door travel time is the ticket booking process, where in most cases net travel times of a given travel mode and not door-to-door travel times are indicated (Sauter-Servaes et

<sup>7</sup> Zurich-Paris by plane: total travel time = 3h 40 min; total travel time was calculated as follows: 10min (transfer from Zurich Main Station – Zurich Airport) + 1h 30min (check-in/check-out) + 1h 15min (flight time between departure and landing = net travel time<sub>1</sub>) + 45min (Paris Charles de Gaulle Airport – Paris Gare de Lyon) = 3h 40 min. (Source: Own calculations based on google.com/maps and google.com/flights).

<sup>8</sup> Zurich-Paris by train (direct route): total travel time = net travel time = productive travel time = 4h 17 min. (Sources: SBB.ch, google.com/maps, SNCF.com).

al., 2019). It is probable that the information provided on booking platforms is used as the starting point to compare calculations of travel time and thus, may have an anchoring effect on judgment (see Tversky & Kahneman, 1974). In the case of flight ticket booking platforms, flight times correspond to the travel time between takeoff and landing (net flight travel time<sub>1</sub>) without accounting for access time, check-in and baggage claim. Contrarily, indicated train travel times correspond to the time needed to get from one city center to the next (net train travel time<sub>1</sub>). Given these considerations, the following hypothesis is tested.

*H2. Comparisons between the travel time of the flight and the train trip are not made based on the total travel time of the flight and train trip, but rather on the net travel time.*

### **2.3 Familiarity with train travel**

The theory of planned behavior proposes that social behavior is reasoned as attitudes, subjective norms and perceptions of behavioral control are guided by beliefs, which result in intentions and ultimately action (Ajzen, 1991). The rational nature of this model has been challenged by a distinct stream of literature suggesting that measures of habit can be better predictors of behavior (e.g., Triandis, 1977; Verplanken et al., 1997). Habits are distinct from other behaviors in that they are repetitive, automatic and goal-oriented (Bargh, 1989). In line with the findings by Verplanken et al. (1997), Kenyon and Lyons (2003) show that the majority of travelers make automatic and habitual mode choices and that they may be unaware of viable alternative travel modes as they only rarely consult information about substitutes. Following this logic, people who have a habit of flying may be less likely to seek information about long-distance train travel.

In the context of train and air travel, Bieger and Laesser (2004) discover that the strength of a familiarity effect may lead to relative advantages for travel modes that people are familiar with. When comparing different travel modes to get from Zurich to Berlin and Freiburg to Leipzig, the authors find that familiarity and sympathy towards travel modes have the most significant positive effect on daytime train connections (Bieger & Laesser, 2004). As the study by Bieger and Laesser was conducted when low-cost airline offers were less ubiquitous than today, train travel may no longer have a relative advantage to air travel. Instead, the growth in demand for flights could be a result of the fact that taking the plane has become the obvious first best option for the general public. Compared to flights, train travel may still have an advantage when it

comes to the familiarity effect. People who use public transportation are also more likely to be more familiar with train travel. Against this backdrop, the following hypothesis investigates the effect of familiarity with public transportation on the consideration of long-distance train travel.

*H3. Familiarity with train travel in a general sense (e.g., public transportation use, ownership of travelcards) leads to a higher possibility of considering taking the train instead of a plane.*

Study 2 is based on a field intervention and has the aim of exploring the role of familiarity with international, long-distance train travel. Research on breaking flying habits and fostering low-carbon, long-distance travel modes remain an understudied research area (Sussman et al., 2020). Therefore, the following hypotheses draw on insights from research that investigates strategies to break car habits and foster public transportation use.

In their study, Kenyon and Lyons (2003) investigate the role of information for modal changes. They find that information provision about alternative travel mode options in response to a single journey inquiry can challenge existing perceptions about the dominant mode and disrupt habitual travel choices. Experience, which is closely linked to habit and attitudes, seems to play an important role as well (Kenyon & Lyons, 2003). Without experience, assumptions inform attitudes about public transportation (Kenyon & Lyons, 2003). Inexperienced public transportation users tended to be unfamiliar with information sources and thus associated a higher planning effort and forethought with public transportation use, whereas car travel appeared psychologically more comfortable (Kenyon & Lyons, 2003). The authors also found a correlation between low experience and negative attitudes towards public transportation, based on which they suggest that actual experience could potentially remove an important barrier to increasing public transportation use.

Following these insights, the information about long-distance train travel options and the train travel experience itself is expected to remove the barrier to long-distance train travel, particularly for inexperienced train travelers. In contrast, the students who have been traveling long-distance by train on a regular basis prior to the field intervention should already feel more at ease with long-distance train travel. As such, the latter are expected to have higher intentions to travel by train from the outset, while occasional train travelers will likely be more affected by the intervention.

*H4. The increase in intentions to travel by train in the future will be more pronounced for the case of inexperienced long-distance train travelers than for regular train travelers.*

Trialability is one of the five attributes of an innovation which, according to Rogers (2010), accelerate diffusion. Trial experience as a key soft measure to behavior change has also been the main assumption underlying studies that have used free public transportation passes to break car habits. In this context, previous research has tested the effectiveness of offering a free one-month travelcard on attitudes toward public transportation and on breaking car habits (see Fujii & Kitamura, 2003; Thøgersen & Møller, 2008). Following these studies, hypothesis 5 investigates the effect of becoming familiar with international, long-distance rail travel on future intentions.

*H5. Long-distance train travel experience increases intentions to travel by train in the future.*

### **3 Study 1: Representative survey**

#### **3.1 Survey and sample**

Data was collected in April 2019 through a representative survey (see Table 1) on consumer preferences and perceptions on renewable energies, mobility and climate policy in Switzerland (N=1021). Given the timeliness of the topic, several questions focused on travel mode choices. Respondents were recruited from a Swiss online consumer panel through a professional market research company<sup>9</sup>.

The Swiss case is particularly interesting for studying behavior change towards long-distance travel: Geographically, Switzerland is located in the heart of Europe and many destinations are easily accessible by trains as well as planes. Also, the Swiss railway system has been rated as number one in Europe thanks to its intensity of use<sup>10</sup>, primarily driven by passenger traffic (Duranton et al., 2017). Thus, the Swiss tend to be more familiar with train travel than other populations, but at the same time are rather frequent flyers, as pointed out in Section 1 (see Global Sustainable Tourism Dashboard, 2018).

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<sup>9</sup> The panel consists of 100'000 registered Swiss individuals who have been actively recruited through Intervista. <https://www.intervista.ch/panel/>

<sup>10</sup> Duranton et al. (2017) measure intensity of use by means of passenger and goods volume (i.e., extent to which rail transportation is used by passengers and freight companies) whereby they define passenger volume as the number of passengers multiplied by kilometers traveled divided by a country's population.

**Table 1** Study 1, Demographic characteristics of the sample.

| Variables                       |                                        | Sample (N=1021) <sup>c</sup> | Swiss Population <sup>c,d</sup> |
|---------------------------------|----------------------------------------|------------------------------|---------------------------------|
| Gender                          | Female                                 | 51%                          | 51%                             |
|                                 | Male                                   | 49%                          | 49%                             |
| Age <sup>a</sup>                | 15-19                                  | 6%                           | 6%                              |
|                                 | 20-29                                  | 16%                          | 15%                             |
|                                 | 30-44                                  | 25%                          | 25%                             |
|                                 | 45-59                                  | 26%                          | 27%                             |
|                                 | 60+                                    | 27%                          | 26%                             |
| Region<br>(excl. Ticino)        | Western Switzerl.<br>(French-speaking) | 25%                          | 25%                             |
|                                 | Alps & Prealps                         | 24%                          | 24%                             |
|                                 | Swiss Plateau West                     | 22%                          | 22%                             |
|                                 | Swiss Plateau East                     | 29%                          | 29%                             |
| Political Attitude <sup>b</sup> | Right-wing                             | 45%                          | 51%                             |
|                                 | Center                                 | 27%                          | 23%                             |
|                                 | Left-wing                              | 21%                          | 27%                             |
| Education                       | Low/medium                             | 58%                          | 56%                             |
|                                 | High                                   | 42%                          | 44%                             |

<sup>a</sup>People below 15 years old are not included in the sample. Therefore, the averages for the Swiss population were adjusted to meet the sampling criteria.

<sup>b</sup>For the analysis at hand, the seven political parties represented in the national parliament were grouped into three main categories: right-wing (SVP, FDP), center (CVP, BDP, GLP) and left-wing (SP, Green). 7% of respondents indicated “other/no party”.

<sup>c</sup>Chi-square test results revealed that there are no statistically significant differences between the sample in Study 1 and the Swiss population data.

<sup>d</sup>Data sources: Age, gender and education data are drawn from the Swiss Federal Statistical Office (2018a). Region data is based on Swiss Federal Statistical Office (2018b). For political attitudes the seating distribution of the Swiss national parliament was used as a data source (Swiss Parliament, 2019).

## 3.2 Measures

### 3.2.1 Consideration of taking the train as a viable alternative to the plane

The survey included questions about whether respondents consider the train as a viable alternative option when traveling long-distance (>300km) within Europe (e.g., Zurich-Paris/Zurich-Frankfurt). The aim was to measure more general preferences as opposed to measuring the preference of one specific travel route. To maintain the comparability of the results, the reference points (Zurich-Paris/Zurich-Frankfurt) were included. Respondents were asked to indicate whether they perceived the train trip as a viable alternative to the flight for their business and private travels respectively. This question was asked on a seven-point scale with “do not agree” vs. “agree” at the two

extremes with no other indication on the scale. Moreover, it included an option to indicate that someone does not travel long-distance within Europe for business or private purposes.

### **3.2.2 The relative importance of time perception**

As a follow-up to the previous question, respondents were clustered into two groups, likely train travelers and unlikely train travelers, based on whether they regard the train to be a viable option (5-7 on the seven-point scale) or not (1-3). Both groups were asked to indicate the relevance of several reasons (seven-point scale) for their respective preferences (see Table 2). Most criteria presented to respondents were derived from literature on modal choice generally and between train and plane more specifically. Further reasons were added to explore newly emerging trends in a time of changing social norms at the societal level and to bring novelty into existing literature.

**Table 2** Criteria for modal choice between air and train travel.

| Sub-samples                                           | Modal choice criteria                                                    | Literature streams                                          | Academic articles                                                                                                         | Emerging trends & newspaper articles                                                                                 |
|-------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Business & private travelers                          | Travel time                                                              | Modal choice; competition of aviation & HSR                 | Bieger & Laesser, 2004; Steer Davis Gleave, 2006; European Commission, 2010; Cascetta et al., 2011; Behrens & Pels, 2012. |                                                                                                                      |
|                                                       | Travel cost                                                              | Modal choice; competition of aviation & HSR                 | Bieger & Laesser, 2001; Steer Davis Gleave 2006; European Commission, 2010; Steer Davis Gleave, 2016.                     |                                                                                                                      |
|                                                       | CO <sub>2</sub> emissions                                                | Modal choice & ecological concern                           | Hares et al., 2010; Cohen et al., 2011; Higham et al., 2016.                                                              | Changing social norms at the societal level & flying shame (e.g., Hoikkala & Magnussen, 2019; Wilkes & Weiss, 2019). |
|                                                       | Low complexity of the train/flight ticket booking process                | Information access; ease of online ticket booking processes | Cheng & Huang, 2014; Dedeke, 2016.                                                                                        |                                                                                                                      |
|                                                       | Punctuality of the train/flight                                          | Modal choice; competition of aviation & HSR                 | Bieger & Laesser, 2001; Steer Davis Gleave, 2016.                                                                         |                                                                                                                      |
|                                                       | Other reasons                                                            |                                                             |                                                                                                                           |                                                                                                                      |
| Additional reasons for business travelers             | Possibility to work during the train trip/flight                         | Travel time utility                                         | Fowkes, 2001; Mokhtarian & Salomon, 2001; Lyons & Urry, 2005; Jain & Lyons, 2008; Wardman & Lyons, 2016.                  |                                                                                                                      |
|                                                       | Active support of train travel/flight by my company                      | Modal choice & corporate travel policies                    | Cohen et al., 2018                                                                                                        | Climate friendly corporate travel policies (e.g. Ro, 2019)                                                           |
| Additional reasons for business/private air travelers | Earn miles                                                               | Customer value of air travel                                | Bieger et al., 2007                                                                                                       |                                                                                                                      |
|                                                       | I have never considered the train as an alternative option to the plane. | Habit & the role of information                             | Kenyon & Lyons, 2003                                                                                                      |                                                                                                                      |

### 3.2.3 Familiarity with train travel

Apart from the measures of travel time and productive travel time, respondents were asked to indicate how often they use public transportation on a five-point scale (1=once a day, 2=once a week, 3=once a month, 4=once a year, 5=never). For the subsequent data analysis, public transportation users are coded as infrequent (1=once a year; never), moderate (2=once a month) and frequent (3=once a week, once a day) users.

The frequency of public transportation use may depend on a respondent's specific commute. Thus, in addition to the "frequency of public transportation use", respondents were asked whether they own (1) no travelcard, (2) a GA travelcard<sup>11</sup> (3) a half fare travelcard, (4) a half fare travelcard in addition to a point-to-point travelcard, (5) a point-to-point travelcard (and no half fare travelcard), (6) any other kind of travelcard. This categorization allows measuring the familiarity with public transportation use in more general terms. It also comes closer to a measure of habit, as people who have a travelcard are automatically more compelled and inclined to use public transportation in general without thinking about alternatives.

## 3.3 Data analysis and results

### 3.3.1 Considering the train as an alternative option

Out of the total sample (N=1021), 91% (N=932) of respondents indicated that they travel long-distance within Europe for private purposes, while 9% (N=89) do not. Of these 932 private travelers, 18% (N=170) did not view the train as a viable option for their private trips (scale points 1-3), while those who did (scale points 5-7) made up 71% (N=658). 11% of respondents (N=104) were unsure (scale point 4) as to whether they consider the train as a viable alternative and were not included in the further analysis.

50% (N=508) of the overall respondents indicated that they go on business trips. Thereof, 67% (N=340) consider the train as a viable option, whereas 21% (N=106) do not. The remaining 12% were unsure about train travel being a viable option (N=62).

These first insights show that a clear majority of business (67%) and private travelers (71%) are likely train travelers as they (rather) consider the train as an alternative option for their long-distance travels (>300km) within Europe.

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<sup>11</sup> A GA travelcard allows for unlimited travel on the Swiss national railways (SBB) and on most other public transportation routes. (Source: <https://www.sbb.ch/en/travelcards-and-tickets/railpasses/ga.html>).

### 3.3.2 Time perceptions: travel time and travel time productivity

The descriptive results shown in Figure 1 give a first indication that people who consider the train as a viable option have very different perceptions about relevant reasons for travel mode choices as opposed to people who always choose to fly. While likely train travelers see manifold benefits of the train trip, likely air travelers mainly have three reasons for their preferred travel mode: total travel time, travel cost and punctuality.

In addition to the descriptive results, a one-way ANOVA<sup>12</sup> shows that the differences between likely train and air travelers are, in all cases, statistically significant for private and business travelers (see Appendix A). Likely train travelers find the following reasons to be significantly more important compared to likely air travelers<sup>13</sup>: CO<sub>2</sub> emissions, travel time productivity\*, the punctuality of the travel mode, low complexity of the booking process, and the preferred travel mode being actively supported by their company\*. Contrarily, likely air travelers mainly find total travel time but also travel cost to be significantly more relevant as opposed to likely train travelers.

For business travelers, the difference in perceptions is particularly pronounced in the case of travel time productivity. Likely train travelers find travel time productivity to be relevant. At the same time, likely air travelers find travel time productivity not only to be significantly less relevant than likely train travelers, but also rather irrelevant as such. These results show support for H1, suggesting that travel time valuations may have an effect on mode choice between the train and plane.

A further noteworthy result concerns the mean for “never having considered the train as an alternative option” as it is slightly above 4 for business and slightly below 4 for private air travelers. This implies that likely private air travelers have a weaker flying habit and may be somewhat more aware of the option to take the train.

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<sup>12</sup> Given that the group sizes of people who consider the train (likely business train travelers: N=340; likely private train travelers: N=658) are larger than the group sizes of people who do not consider the train as a viable option (likely business air travelers: N=106; likely private air travelers: N=170), the test of homogeneity of variances turned out to be significant for all tested reasons except for company support (p=0.6) and travel cost (p=0.281). For these reasons, the results from the robust test of equality of means (Welch's test) are reported here.

<sup>13</sup> Reasons that only apply to business travelers are marked with \*.

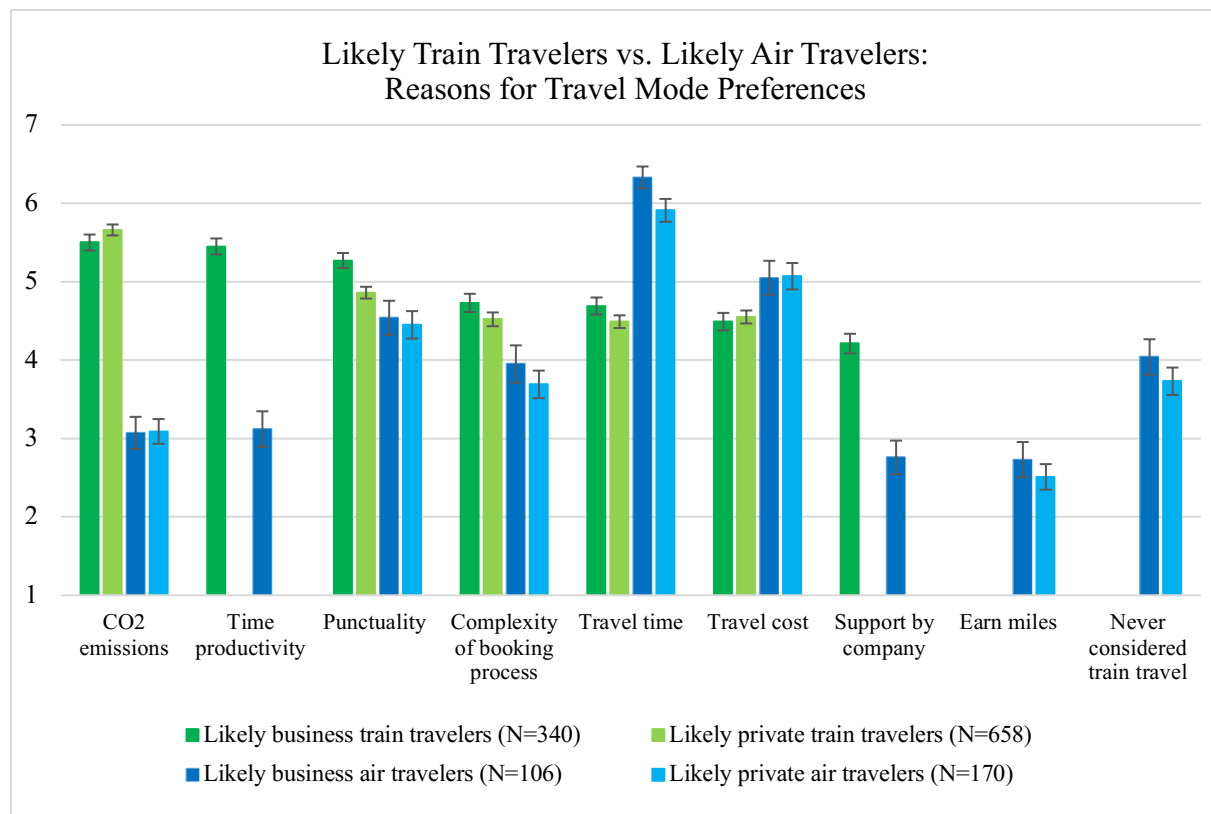


**Figure 1** Reasons for considering the train as a viable option vs. not a viable option.

### 3.3.3 Familiarity with train travel

The effect of both familiarity measures (“public transportation use” and “ownership of a travelcard”) on the consideration of train travel was investigated using multiple one-way ANOVA.

#### 3.3.3.1 Frequency of public transportation use and consideration of long-distance train travel

Figure 2 illustrates the effect of frequency of public transportation use on the consideration of long-distance train travel (see Appendix B).<sup>14</sup> Both one-way ANOVA show significant effects for the frequency of public transportation use on the consideration of long-distance train travel for private and business travelers. Pairwise comparisons between the three groups, frequent, moderate and infrequent public transportation users, provide more detailed insights (see Appendix C). For the case of private travelers, the Games-Howell post-hoc analysis revealed statistically significant

<sup>14</sup> The test of homogeneity of variances turned out to be significant for the consideration of train travel for business and private purposes. Thus, robust test of equality of means (Welch’s test) as well as Games-Howell post-hoc test results are reported.

differences between all three groups, although at different p-values. The mean level of consideration increased from infrequent to moderate public transportation users, from moderate to frequent users and from infrequent to frequent users. For the case of business travelers, the three groups vary to a lesser extent. The Games-Howell post-hoc analysis only showed statistically significant differences between frequent and infrequent public transportation users.

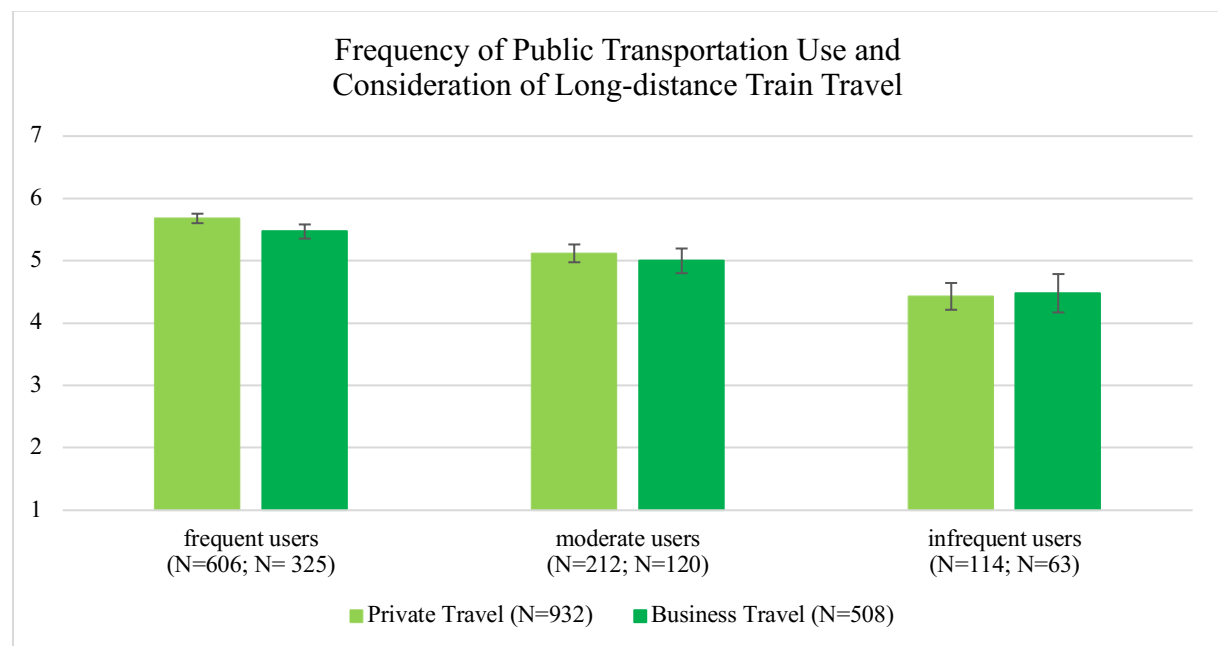


**Figure 2** Long-distance train travel consideration levels for frequent, moderate and infrequent public transportation users.

### 3.3.3.2 Ownership of a travelcard and consideration of long-distance train travel

Figure 3 illustrates the effect of owning different types of travelcard subscriptions on the consideration of long-distance train travel.<sup>15</sup> Also for this measure, one-way ANOVA resulted in statistically significant effects on the consideration of long-distance train travel for private and business travelers (see Appendix D). According to results of the Games-Howell post-hoc analysis (see Appendix E), private as well as business travelers who do not have a travelcard reveal a significantly lower consideration of long-distance train travel than respondents with a GA, a half fare (without an additional subscription) and another type of travelcard. Business and private travelers who only

<sup>15</sup> The test of homogeneity of variances turned out to be significant for the consideration of train travel for business and private purposes. Thus, robust test of equality of means (Welch's test) as well as Games-Howell post-hoc test results are reported.

own a point-to-point travelcard reveal relatively low levels of consideration of long-distance train travel. As the large majority of this group, 97% (N=57) of private and 94% (N=32) of business travelers, also indicated that they use public transportation frequently, this may suggest that this group limits its public transportation use to specific commutes.



**Figure 3** Long-distance train travel consideration levels for different types of travelcards.

These results confirm H3 as they suggest that familiarity with train travel in general terms is linked to higher levels of long-distance train travel consideration. For one, the frequency of public transportation leads to a higher likelihood of long-distance train travel consideration. Secondly, particularly people who own a travelcard that is generally valid for the national railway system (i.e., GA or half fare cards) are also more likely to consider long-distance train trips. This is not the case for people who own a travelcard that is limited to a specific commute (i.e., point-to-point travelcards).

## 4 Study 2: Intervention study

### 4.1 Survey, intervention and sample

Study 1 has shown that familiarity and time perceptions correlate with stated travel mode preferences. Will these preferences hold in a real-life decision-making context? To answer this question, Study 2 consists of a field-based intervention study with international business students ( $N=50$ ) traveling long-distance (see Appendix F for a comparison of the samples used in Study 1 and Study 2). International business students are an important sample for studying modal choice as they are likely to travel relatively frequently for their careers. Also, they may take on influential roles in the future<sup>16</sup>. Participants of the intervention study included students of a master's course offered in parallel at nine universities<sup>17</sup> followed by a two-day Model UNFCCC<sup>18</sup>. Thus, after attending a coordinated, semester long course on climate science, international policymaking and economics at their local universities, students from eight universities traveled to the University of Cologne for a simulation of the United Nations' climate policy negotiations.

Study 2 is based on a panel design including two waves. The first online survey ( $t_0$ ,  $n = 102$ ) was sent out at the beginning of the course (February-March 2019) and the second one ( $t_1$ ,  $n = 59$ )<sup>19</sup> three weeks after the 2-day role-play (June 2019). The drop-out rate was 42%. The final sample ( $N=48$ )<sup>20</sup> consisted of students aged 20-29. 50% were male and 50% female students. The intervention took place between the two waves and consisted of an offer of *low-carbon travel grants*, a monetary incentive that was only provided to students if they chose to travel by train to Cologne. Students were informed about the travel grants in class by their professors who coordinated travel arrangements with their students. For reasons of perceived distributive justice among students, the amount of travel grants varied based on the distance to the destination (University of Cologne) (see Table 3). Table 3 provides detailed information about the trip and sample characteristics of Study 2.

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<sup>16</sup> For information on CEMS Alumni see: <http://www.cemsalumni.org/news/facts-figures/>

<sup>17</sup> These nine universities are all part of the Global Alliance in Management Education (CEMS).

<sup>18</sup> UNFCCC stands for United Nations Framework Convention on Climate Change. For a detailed outline of the course and role play see Paschall and Wüstenhagen (2012) or [www.modelunfccc.org](http://www.modelunfccc.org)

<sup>19</sup> Although in total 59 students had taken part in both survey waves, students from the University of Cologne ( $N=9$ ) were not included in the final sample.

<sup>20</sup> People who traveled by train/plane one-way respectively ( $N=2$ ) were excluded from the final sample (see section 4.2.4).

**Table 3** Study 2, Characteristics of the sample.

| Home University                             | Nr. of Students (N=126) | Nr. of Survey Respondents (N=50) | Distance to Destination in km <sup>a</sup> | Travel Grants <sup>g, h</sup> (return trip) | Net Travel Time 1 <sup>c</sup> (one-way) |                    | Estimation of Ticket Prices (return trip) <sup>f, g</sup> |                    |
|---------------------------------------------|-------------------------|----------------------------------|--------------------------------------------|---------------------------------------------|------------------------------------------|--------------------|-----------------------------------------------------------|--------------------|
|                                             |                         |                                  |                                            |                                             | Train <sup>b</sup>                       | Plane <sup>e</sup> | Train                                                     | Plane <sup>e</sup> |
| Rotterdam School of Management              | 29                      | 8                                | 203.89                                     | 50                                          | 3h                                       | 3h <sup>d</sup>    | 75                                                        | 255                |
| University of St.Gallen                     | 19                      | 14                               | 428.41                                     | 100                                         | 6h                                       | 1h <sup>d</sup>    | 180                                                       | 155                |
| Bocconi University                          | 8                       | 4                                | 630.84                                     | 150                                         | 8h<br>30min                              | 1h<br>30min        | 350                                                       | 70                 |
| Vienna University of Economics and Business | 9                       | 3                                | 743.00                                     | 150                                         | 8h                                       | 1h<br>30min        | 210                                                       | 260                |
| Corvinus University of Budapest             | 11                      | 7                                | 955.98                                     | 200                                         | 11h<br>30min                             | 2h                 | 320                                                       | 207                |
| Warsaw School of Economics                  | 28                      | 10                               | 979.82                                     | 200                                         | 11h                                      | 2h                 | 210                                                       | 134                |
| ESADE Barcelona                             | 13                      | 3                                | 1124.13                                    | 250                                         | 12h                                      | 2h                 | 480                                                       | 227                |
| Stockholm School of Economics               | 9                       | 1                                | 1167.42                                    | 250                                         | 16h<br>30min                             | 2h                 | 280                                                       | 177                |

<sup>a</sup> Distances were calculated between the city center of Cologne and the city center of the home university. (Source: [www.luftlinie.org](http://www.luftlinie.org)).

<sup>b</sup> Time indications correspond to the fastest train connections available on [trainline.com](http://trainline.com).

<sup>c</sup> Indications of Net Travel Time<sub>1</sub> (=in-vehicle travel time) are rounded to the nearest half hour.

<sup>d</sup> There is no local airport available for these universities. For St. Gallen flight time starts at Zurich Airport. For Rotterdam, flight time starts at Amsterdam Airport.

<sup>e</sup> Flights between Amsterdam-Cologne and Stockholm-Cologne require one stop. All other flight connections are non-stop flights.

<sup>f</sup> The prices are outlined for two weeks in advance booking available on [swoodoo.com](http://swoodoo.com). The prices which most closely align with the net travel times are indicated.

<sup>g</sup> All prices and travel grants are indicated in EUR.

<sup>h</sup> The indicated amounts correspond to the maximum travel grants available to students. The maximum grant amounts were defined based on net train travel times. Train tickets that were below the max. travel grant amount were refunded for the full amount of their ticket price, but not more.

## 4.2 Measures

### 4.2.1 Intention to travel by train

Intention to travel by train in the future represents a higher commitment to train travel than consideration of the train as a viable alternative to the plane. As Study 2 took place in a real-life decision-making context and the goal was to measure the intervention

effect, the dependent variable asked respondents about their intention. The question reads: “How likely is it, that you will travel more frequently long-distance (>300km) by train in the future?” Answer options ranged from extremely unlikely to extremely likely on a seven-point scale.

#### 4.2.2 The reference point for making travel time comparisons

Several questions were dedicated to investigating the role of travel time for low-carbon travel choices. To explore how comparisons of the total travel time between different travel modes are made, respondents were first asked about their maximum accepted train travel time. In a second step, students were asked to indicate their maximum additional accepted hours of train travel above the duration of the flight. Subsequently, students were asked which definition of flight time they referred to when indicating their accepted additional train travel time above the duration of the flight. Answer options included the total travel time and the two variations of net travel time definitions (see Figure 4).

#### 4.2.3 The relative importance of time perceptions

To gain insights into the relative role of time perceptions for their mode choice, students were first asked whether they had gone to Cologne by train, plane, or train and plane one-way respectively. As a follow-up question, students were asked to indicate the importance of different reasons for their modal choices on a seven-point scale (extremely relevant vs. extremely irrelevant).

Students had a few additional answer options compared to the ones included in Study 1. These supplementary questions were included to adhere to students’ specific decision-making situation (e.g., influence of peers) and are highlighted in bold in the following.

*All students:* travel time; travel cost; CO<sub>2</sub> emissions; low complexity of the train/flight ticket booking process; punctuality of the train/flight; possibility to work during the train trip/flight; active support of traveling by train/plane by my **university**; **travel comfort**; **fellow students’ travel mode choice**; **lecturer’s travel mode choice**.

*Only train travelers:* Students who traveled by train were additionally asked to indicate the relevance of the **travel grant**.

*Only flyers:* Earn miles; I was not aware of the option to travel to Cologne by train; **I was not aware of the travel grants for train tickets**.

The similarity of this question with the one asked in the national survey allows exploring whether the relative importance of time perceptions is comparable in a

situational, real-life context as opposed to results from stated preferences in the context of a representative survey.

#### 4.2.4 Familiarity with long-distance train travel

As the sample consists of international business students, and public transportation systems can diverge significantly between the eight countries, students were not asked whether they have a travelcard. In the second study, measurements of familiarity were more specific to long-distance travel. Thereby, the focus of Study 2 was twofold. For one, the goal was to find out whether the intervention was effective in making students more familiar with train travel and thus increasing their intention to travel more frequently by train in the future. The second aim was to investigate the role of train travel behavior prior to the trip to Cologne on intentions to travel by train more frequently in the future. For this purpose, two independent variables were operationalized as follows: The first measure consists of the question about how students traveled to Cologne, the answer options being train (N=35), plane (N=13) and train/plane one-way (N=2). Due to the small group of people who traveled by train/plane one-way respectively, this group was not included in the analysis. Secondly, students were asked to indicate the past frequency of their long-distance travels on a six-point scale. For the data analysis, respondents were categorized into two groups, namely occasional and regular train travelers<sup>21</sup>.

### 4.3 Data analysis and results

#### 4.3.1 Potential bias underlying the comparison of total travel time

Descriptive results show that in both survey waves approximately half of the respondents (N<sub>wave 1</sub>=24; N<sub>wave 2</sub>=26) did not use the total travel time (i.e., the door-to-door calculation of the journey by plane; see Figure 4) as a reference point when comparing train with air travel time. The other half used one of the two net travel time<sub>1,2</sub> definitions as a reference point. These results support H2 in that travel time comparisons between air and train travel are not made based on total travel time calculations.

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<sup>21</sup> Answer options included 1="I have never traveled long-distance by train"; 2= "The train trip related to the CEMS Model UNFCCC in Cologne was my first long-distance train trip"; 3= "In the past, I have traveled by train (long-distance) on a few single occasions"; 4= "On average, I travel (long-distance) by train once a year"; 5= "On average, I travel (long-distance) by train two to four times a year"; 6= "On average, I travel (long-distance) by train more than five times a year". Categories 1 through 3 resulted in occasional and categories 4 through 6 in regular train travelers.

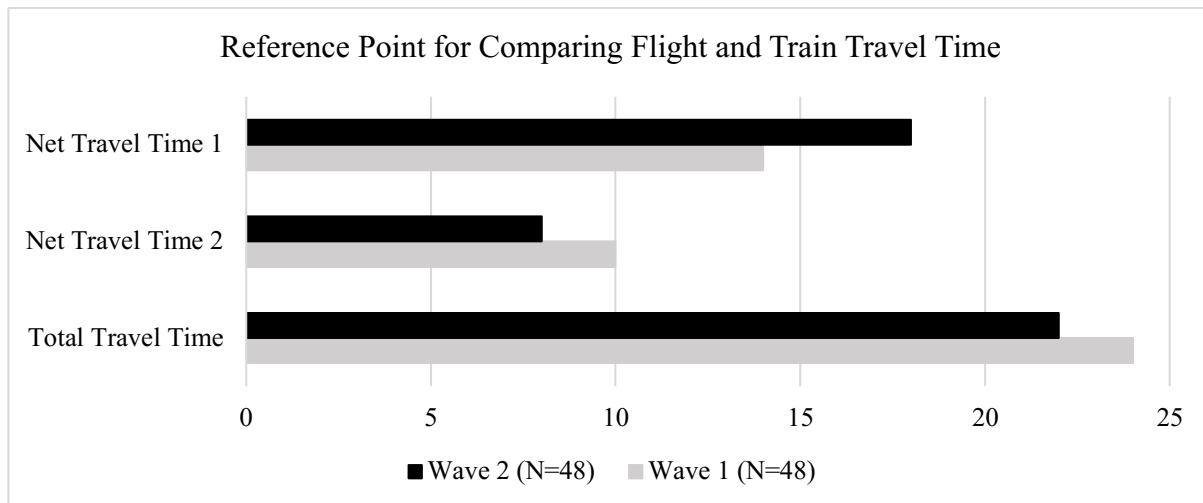


**Figure 4** Descriptive results for the reference point for making flight and train travel time comparisons.

#### 4.3.2 Travel mode choices: travel time and time productivity

The descriptive results for Study 2 show that the price argument is central to train and air travelers (see Figure 5). In fact, train travelers rated travel grants as the most relevant argument for their modal choice. This demonstrates that monetary incentives can have an effect on students' modal choices. It should be noted, that, to some extent, this result may have been influenced by the travel grants' attractiveness. Also, student samples tend to be more price-sensitive than other samples. Apart from travel grants, the next most important reason to travel by train was CO<sub>2</sub> emissions ( $M=6.03$ ,  $SD=1.043$ ), followed by travel time productivity ( $M=5.43$ ,  $SD=1.243$ ), active support of train travel by the university ( $M=5.06$ ,  $SD=1.878$ ), ticket price ( $M=4.69$ ,  $SD=1.952$ ), travel comfort ( $M=4.57$ ,  $SD=1.820$ ) and influence of peers ( $M=4.49$ ,  $SD=2.161$ ). Contrarily, students who chose to fly had very different reasons for their modal choices. Air travelers indicated three main reasons for their modal choice: total travel time ( $M=6.38$ ,  $SD=0.961$ ), followed by ticket price ( $M=6.08$ ,  $SD=1.320$ ) and travel comfort ( $M=4.62$ ,  $SD=1.446$ ). Similar to Study 1, air travelers indicated significantly fewer reasons to be important compared to train travelers.

Consistent with Study 1, air and train travelers reveal very distinctive perceptions of total travel time and travel time productivity. While travel time productivity is one of the most important arguments in favor of the train trip, time productivity has a mean below 4 in the case of air travelers. Thus, time productivity is not a relevant argument for this group ( $M=2.85$ ,  $SD=1.519$ ). The opposite is the case for travel time, which is

the most relevant argument in favor of flying but seems to be somewhat irrelevant for train travelers ( $M=3.51$ ,  $SD=1.755$ ). Thus, Study 2 also finds support for H1.

To further investigate the discrepancies between air and train travelers, the results of one-way ANOVA are presented in the following. Significant differences at  $p<0.001$  were found for time productivity (Welch's  $F(1,18.316)=30.082$ ,  $p=.000$ ), total travel time (Welch's  $F(1,39.025)=51.808$ ,  $p<.001$ ), CO<sub>2</sub> emissions (Welch's  $F(1,17.865)=52.740$ ,  $p<.001$ ) and active support by the university (Welch's  $F(1,32.474)=34.197$ ,  $p<.001$ ). Differences at less significant levels were found for the relevance of the ticket price (Welch's  $F(1,31.955)=7.965$ ,  $p<.01$ ) and for the lecturer's influence (Welch's  $F(1,32.821)=5.346$ ,  $p<.05$ ). As pointed out above, the high mean score for the importance of travel grants indicates that in a situation without monetary incentives, train travelers would have found the ticket price to be more important. For punctuality of the train/plane, complexity of the ticket booking process, comfort of the chosen travel mode and peer influence, the one-way ANOVA do not find any statistically significant differences between flyers and train travelers.

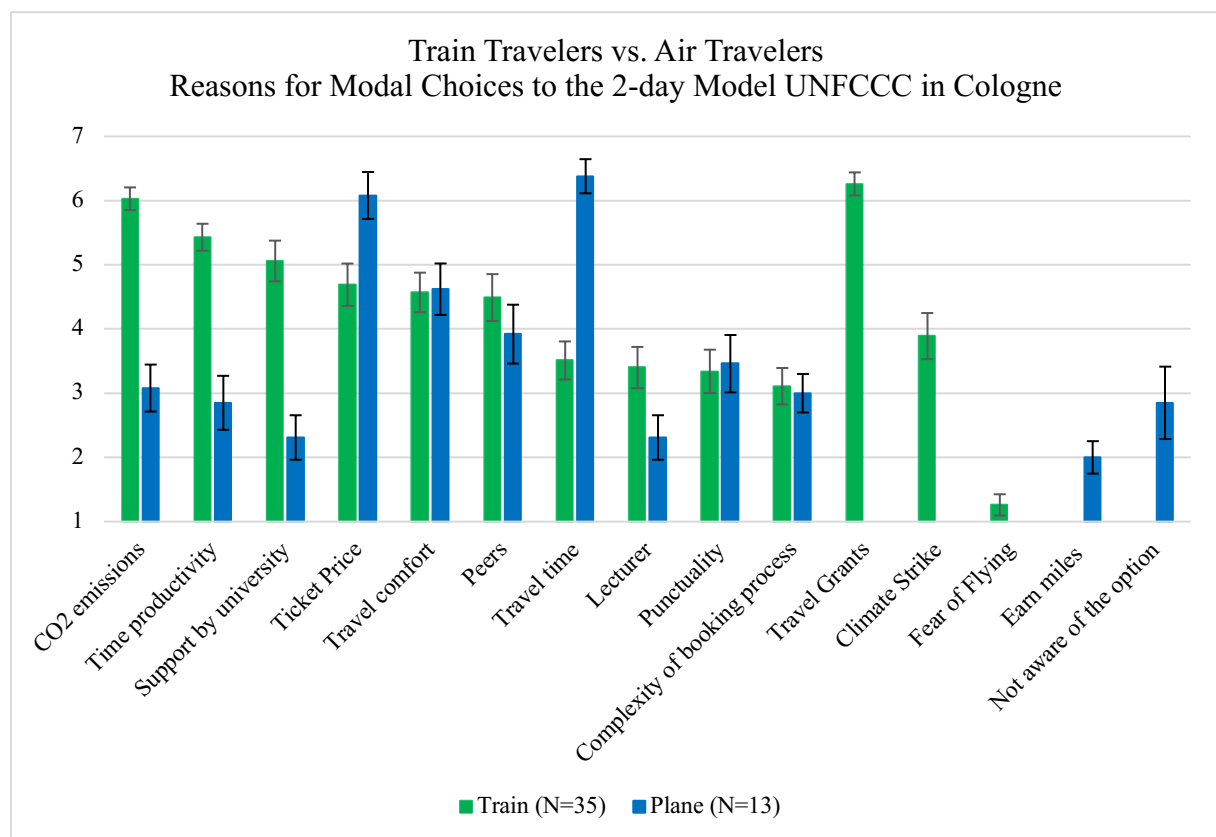


**Figure 5** Reasons for modal choices (train vs. plane) to Cologne.

### 4.3.3 Regular vs. occasional train travelers

Study 1 has shown that familiarity with train travel in general correlates with the consideration of long-distance train travel. To complement these findings, Study 2 further investigates the role of familiarity with long-distance train travel on future intentions. To do so, the two groups of regular and occasional long-distance train travelers are compared (H4) in the following paragraphs.

Paired sample t-tests were conducted for the overall sample (N=48) as well as for regular (N=21) and occasional train travelers (N=27) separately. For the overall sample of respondents that traveled to Cologne (N=48), paired sample t-tests reveal a higher intention to travel by train after the role play compared to before the role play ( $t(47) = -4.134, p = 0.000$ ). The separate paired sample t-test for the group of regular train travelers found evidence for a significant difference between the mean scores in waves 1 and 2 ( $t(20) = -2.335, p = 0.030$ ). However, the difference in intentions to travel by train in the future was more prominent for occasional train travelers ( $t(26) = -3.407, p = 0.002$ ). In fact, their mean was below 4 prior to the intervention (see Figure 6) and increased to a mean above 4 after the intervention. Between group differences of regular and occasional train travelers in wave 1 and 2 were further investigated through two one-way ANOVA (N=48). Thereby, in wave 1, occasional and regular train travelers significantly differed in their intention to travel by train in the future ( $F(1, 11.318) = 7.06, p = 0.011$ ). This is also the case after the intervention, however, at lower statistically significant levels ( $F(1, 7.741) = 5.143, p = 0.028$ ).

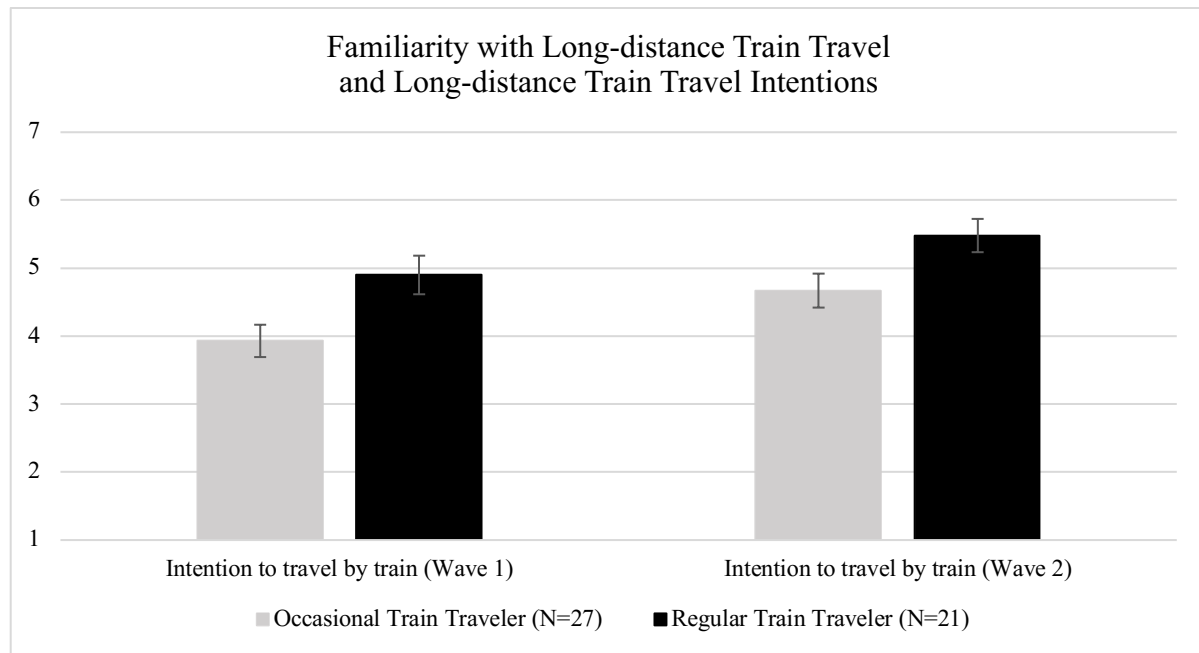


**Figure 6** Future long-distance train travel intentions for occasional and regular long-distance train travelers.

#### 4.3.4 Train travel experience to Cologne

To further explore the role of familiarity, the results for the effect of the train travel experience to Cologne on students' future long-distance train travel intentions (H5) are presented in the following (see Figure 7). For the group of students that traveled to Cologne by train, a paired sample t-test shows significantly higher train travel intentions after traveling to Cologne ( $t(34) = -3.515, p = 0.001$ ). Also for air travelers, a separate paired sample t-test found evidence for a difference between the mean scores in waves 1 and 2 ( $t(12) = -2.214, p = 0.047$ ), but at less statistically significant levels.

Two one-way ANOVA further explore train (N=35) and air travelers' (N=13) travel intentions. Results show that air and train travelers' intentions already differed significantly prior to the intervention ( $F(1, 7.810) = 4.655, p = 0.036$ ). The significant difference became more pronounced after the trip to Cologne ( $F(1, 11.129) = 7.774, p = 0.008$ ), suggesting that the train travel experience to Cologne was effective in increasing train travel intentions.

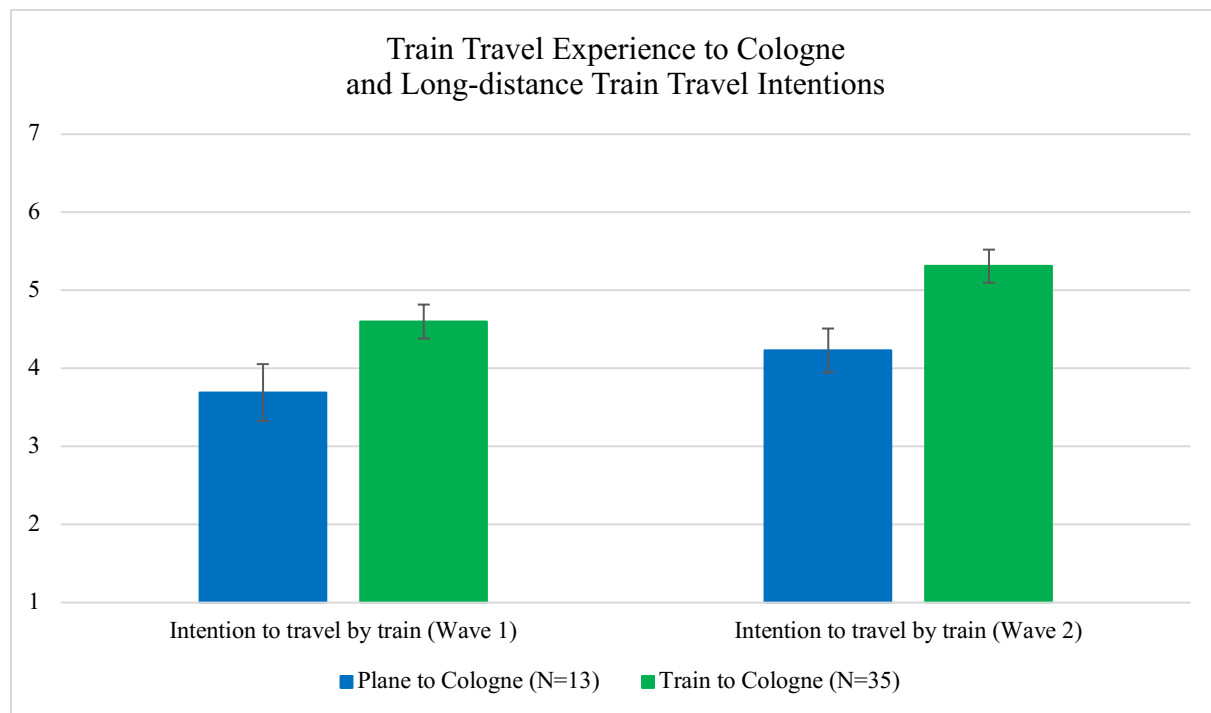


**Figure 7** Future long-distance train travel intentions for train and air travelers

## 5 Discussion

### 5.1 The role of travel time perceptions

#### 5.1.1 Time perceptions differ systematically

The findings of Studies 1 and 2 indicate that (likely) train travelers value productive travel time significantly more than air travelers, while the latter are significantly more concerned about minimizing total travel time. These results support H1 suggesting that there may be systematic differences in (likely) air and train travelers' time perceptions. As such, this study supports the proposal that transport policy design should move beyond assessing travel time as an opportunity cost (see Mokhtarian & Salomon, 2001; Lyons & Urry, 2005; Jain & Lyons, 2008) for the case of long-distance travel. In the future, the extent to which business travelers can use their travel time productively will not only depend on the digitization trend and increasing flexibility of work practices (Wardman & Lyons, 2016), but also on the service quality level of railway companies (Li, 2003; Bouscasse & de Lapparent, 2019; Van Hagen & Van Oort, 2019). In this respect, the willingness of companies and private individuals to pay for increased travel time quality in the context of low-cost air travel needs to be explored.

As opposed to likely train travelers, likely air travelers seem to be mainly concerned about minimizing travel costs and time, but not about travel time productivity. Study 1 provides a possible explanation for this discrepancy between likely air and train travelers. The mean for “I have never considered the train as an alternative option to the plane” was close to 4 (out of 7) in the case of likely business and private air travelers. Thus, likely air travelers are rather unlikely to have thought about the benefits of train travel in an in-depth manner. These results lend support to the findings by Kenyon and Lyons (2003) that travelers do not inform themselves about substitutes but rely on habitual modal choices. In order for likely air travelers to consider the train in the first place, raising awareness about the benefits of train travel may be necessary. Persuasion of a modal change becomes more likely if travelers not only receive information about cost and travel time of different alternatives, but also about key concerns such as comfort and convenience (Kenyon & Lyons, 2003).

### **5.1.2 Climate friendliness is key**

While the productive use of travel time was a key concern of (likely) train travelers in both studies, CO<sub>2</sub> emissions were a slightly more important criterion in favor of the train. The link between sustainable behavior and the preference in favor of the train is in line with an earlier study by Bieger and Laesser (2004). The results of this paper suggest that attitudes towards climate change remain a central driver of (likely) train travelers’ low-carbon travel mode choices. Policymakers seeking to foster low-carbon travel choices should therefore aim at increasing awareness about the large difference in CO<sub>2</sub> emissions between air and train travel.

### **5.1.3 Air and train travel time comparisons**

Half of the respondents in Study 2 used one of the two net travel time<sub>1,2</sub> definitions as a reference point for comparing total air with train travel times. Thus, Study 2 provides initial evidence for a potential bias when making comparisons between train and air travel times. This conclusion can, however, not be generalized beyond the sample of international business students. Research should further explore antecedents to this potential bias with a large representative sample as there is a need to further investigate the hidden travel time costs of air travel. Sauter-Servaes et al. (2019) propose that current travel planning applications indicate net travel times for air travel (i.e., underestimation of waiting times at airports) and total travel times for train travel (Sauter-Servaes, 2019), thereby reinforcing travelers’ existing biases.

## 5.2 The role of familiarity

### 5.2.1 Familiarity with public transportation use

In the context of the market entry of low-cost carriers, Bieger and Laesser (2004) found familiarity to have a positive effect on the preference for daytime train connections. In a context in which short-haul flights have become much more common, this paper was able to confirm the critical role of familiarity with public transportation for the consideration of long-distance train travel. For one, the frequency of public transportation use generally translated into a higher consideration of train travel. Secondly, owning a regular travel pass (GA or a half fare travelcard) was found to be a critical determinant compared to not owning a travelcard. As pointed out by Garcia-Sierra et al. (2015), long-term decisions such as buying a car will affect short-term travel choices. In the realm of public transportation, purchasing a travel pass could be seen as a long-term investment that leads to increased public transportation use. As shown in Study 1, ownership of a travel pass may not only affect short-term modal choices between car and public transportation use. It also seems to have a positive external effect on considering the train instead of the plane. A possible reason could be that travelcard holders are better informed about the variety of train travel options than non-holders. Point-to-point travelcards, which are only valid for a specific commute, are the exception. Although most point-to-point travelcard owners are also frequent public transportation users, they did not reveal a significantly higher consideration of long-distance train travel than non-owners. Previous studies have found the trip purpose to be crucial for modal choices (e.g., Mackie et al., 2001; O'Fallon et al., 2004; Yang et al., 2018). Thus, this group may limit its public transportation use to specific commutes and prefer other modes for other purposes. As such, a point-to-point travelcard purchase is unlikely to translate into short-term modal choices.

In sum, these findings highlight the importance of fostering public transportation use as well as promoting travelcards that are valid beyond a particular commute. It is important to consider that these subscription types can result in positive spillover effects on modal choices that are not directly a part of subscription offers. This insight is relevant for research currently exploring mobility service bundling approaches to increase public transportation accessibility and decrease car use (see, e.g., Guidon et al., 2020).

### **5.2.2 The role of familiarity with long-distance train travel**

While past research has investigated strategies to foster public transportation, the field intervention in Study 2 is one of the first attempts to investigate the effects of train travel experience on intentions to travel by train in the future.

The results of Study 2 find support for H4. Interestingly, occasional train travelers showed rather no intention to travel by train before the intervention (mean below 4 out of 7), while the intention increased significantly and became rather high after the intervention (mean above 4). Thus, increased familiarity and experience with long-distance train travel may be a part of the solution to persuade inexperienced train travelers to switch from plane to train. Study 2 also supports H5, as the intentions of students who traveled to Cologne by train increased after the intervention.

The overall results of Study 2 lend support to extant literature which suggests that experience (Fujii & Kitamura, 2003; Thøgersen & Møller, 2008) and information (Kenyon & Lyons, 2003) about alternative modes can be vital in breaking old habits and considering alternative travel modes. It is, however, remarkable that air travelers' intentions to travel by train significantly increased from a mean below 4 (out of 7) in wave 1 to a mean of 4.9 in wave 2. These results propose that the intervention was also successful in gaining the attention of students who were not part of the train travel experience itself. One possible reason for this may be that interventions within a group can successfully reach people who do not react to the specific incentives introduced through the intervention. Perceived social norms (i.e., fellow students' modal choices and attitudes towards train travel) may partly explain air travelers' change in intentions. Social factors are important drivers of modal choices (Garcia-Sierra et al., 2015). They may additionally explain why regular train travelers, although at lower levels than occasional train travelers, revealed statistically significantly higher intentions after the intervention, although at lower levels than occasional travelers.

## **6 Conclusion**

### **6.1 General conclusions and implications for policy and practice**

This paper finds familiarity with train travel and time perceptions to be important determinants of low-carbon travel mode choices in two independent studies.

Firstly, time perceptions systematically vary between (likely) air and train travelers. The former are mainly concerned about minimizing travel time and the latter highly

value travel time productivity. These results have implications for communication strategies of railway operators. Air traveling habits could be addressed through communication campaigns on the productive use of travel time. As CO<sub>2</sub> emissions were consistently key arguments for considering (Study 1) and choosing (Study 2) train travel, focusing communication messages on time perceptions could be effective in targeting segments that are unresponsive to the climate argument. As such, this strategy could be particularly successful in targeting time-sensitive travelers with positive climate attitudes. Also, motivational campaigns can be more effective in building the basis for behavior change if habits are weak but intentions to change behavior are strong (Gardner, 2008). Thus, campaigns about productive time use are unlikely to result in behavior change of people with a strong flying habit.

Secondly, apart from time, ticket costs may be a key barrier for price-sensitive customer segments or travelers who are rather unfamiliar with the co-benefits of train travel (e.g., travel time productivity). While in both studies travel costs were relevant for (likely) train and air travelers, costs were always significantly more important for (likely) flyers. In Study 2, however, travel grants seemed to be a pivotal motivation to choose the train, which may be because students are a rather price-sensitive traveler segment. Targeting low to middle-income segments with effective pricing strategies could pose an opportunity for policymakers and railway operators. As both studies find that familiarity with train travel can increase customers' awareness of train travel benefits, attractive travelcard offers at the national and international levels may be a worthwhile investment with the aim of building long-term customer relationships. In this respect, students, a target group with a potentially high customer lifetime value, would be particularly interesting. #DiscoverEU<sup>22</sup>, which has allowed for nearly 30'000 18-year olds to become familiar with Interrail travel free of charge, could be a step in the right direction.

Finally, these strategies are likely to be more effective if complementary strategies such as taxes on flight ticket prices follow. The effectiveness of a flight ticket tax will depend on price-elasticities of the demand (Tol, 2007; Falk & Hagsten, 2019) as well as the public acceptance of such a regulatory measure (Higham et al., 2016), which are both subject to national and socio-cultural disparities. As shown by Cousse and

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<sup>22</sup> See: <http://www.youdiscover.eu>

Wüstenhagen (2019), only 30% of Swiss voters would be against a flight ticket tax, which would correspond to a minority of Swiss voters.

## 6.2 Limitations and future research

While this study provides several important insights on low-carbon, long-distance travel mode decision-making, the following limitations are outlined as opportunities for further research.

Both studies included in this paper focus on two specific but relevant samples in terms of studying frequent air travel behavior, namely Swiss travelers as well as international business students. As preferences are context-dependent, scholars could complement the findings of Study 1 by investigating drivers of low-carbon modal choices in the context of other countries. While results of Study 1 are based on a nationally representative sample, the results drawn from international business students in Study 2 are not. There are a number of psychological studies that use student samples (e.g., Bamberg et al., 2003; Hanel & Vione, 2016). However, according to Greenfield (2014) socioeconomic groups can be more distinct from each other than countries. Thus, conclusions drawn from Study 2 (H2, H4, H5) have limited external validity as they are not applicable beyond the sample of international business students. A central value of Study 2 is that its research design goes beyond the investigation of stated preferences. Study 2 reveals preferences formed in a real-life and concrete decision-making context. Thus, Study 2 allowed to identify important intervention points for decarbonizing transportation by investigating actual travel choices of a sample that consists of people who are current frequent air travelers as well as future decision-makers in the private sector. In sum, replicating Study 2 with a larger sample is an opportunity for future research. Methodologically, the replication could either be based on an online experiment or a more large-scale field intervention (e.g., providing financial incentives to travel by train in the context of larger events).

A further limitation of Study 2 relates to its longitudinal design, which was based on a three-month-long interval between the two data collection points. Further exploring the longevity of the effect of long-distance train travel training on intentions and behaviors provides an opportunity for future research. This is particularly important as past research has found a free one-month travelcard to break car travel habits, however, the effect of the free trial experience did not last in the long-term (Thøgersen & Møller, 2008). In the context of long-distance travel, future contributions could investigate

whether field interventions that aim at promoting eco-friendly travel modes and are based on monetary incentives such as travel grants or the #DiscoverEU project can effectively lead to long-term habitual changes.

Finally, travel time perceptions seem to be a fundamental driver of low-carbon travel mode choices. Research should investigate this aspect in more depth as it may turn out to be important when it comes to persuading people to travel long-distance by train. This could entail studies focusing on how different stages of the air and train travel journey (e.g., booking process, retention time) drive travel time perceptions.

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## 8 Appendix

**Appendix A** Study 1, Means and ANOVA, Comparison between likely train and air travelers: Reasons for travel mode choices.

| Reasons for considering the train as a viable option vs. not a viable option. | Mean and standard deviation |                      | ANOVA                                       |
|-------------------------------------------------------------------------------|-----------------------------|----------------------|---------------------------------------------|
|                                                                               | Likely train travelers      | Likely air travelers |                                             |
| <i>Private travelers</i>                                                      |                             |                      |                                             |
| CO <sub>2</sub> emissions                                                     | M = 5.66, SD = 1.78         | M = 3.09, SD = 2.06  | Welch's $F_{(1,238.309)}=220.045$ , p <.001 |
| Punctuality                                                                   | M = 4.86, SD = 1.93         | M = 4.45, SD = 2.28  | Welch's $F_{(1,235.518)}=4.675$ , p <.05    |
| Complexity of the booking process                                             | M = 4.52, SD = 2.25         | M = 3.69, SD = 2.30  | Welch's $F_{(1,259.266)}=18.000$ , p <.001  |
| Travel time                                                                   | M = 4.49, SD = 2.08         | M = 5.91, SD = 1.91  | Welch's $F_{(1,282.348)}=72.093$ , p <.001  |
| Travel cost                                                                   | M = 4.55, SD = 2.12         | M = 5.07, SD = 2.12  | Welch's $F_{(1,255.825)}=7.717$ , p <.01    |
| Earn miles                                                                    | -                           | M = 2.51, SD = 2.12  | -                                           |
| Never considered train travel                                                 | -                           | M = 3.73, SD = 2.28  | -                                           |
| <i>Business travelers</i>                                                     |                             |                      |                                             |
| CO <sub>2</sub> emissions                                                     | M = 5.5, SD = 1.89          | M = 3.07, SD = 2.13  | Welch's $F_{(1,160.02)}=111.513$ , p <.001  |
| Time productivity                                                             | M = 5.45, SD = 1.88         | M = 3.12, SD = 2.34  | Welch's $F_{(1,149.914)}=87.437$ , p <.001  |
| Punctuality                                                                   | M = 5.27, SD = 1.77         | M = 4.54, SD = 2.23  | Welch's $F_{(1,148.360)}=9.494$ , p <.01    |
| Complexity of the booking process                                             | M = 4.73, SD = 2.14         | M = 3.95, SD = 2.45  | Welch's $F_{(1,158.258)}=8.685$ , p <.01    |
| Travel time                                                                   | M = 4.69, SD = 2.02         | M = 6.33, SD = 1.44  | Welch's $F_{(1,244.493)}=84.992$ , p <.001  |
| Travel cost                                                                   | M = 4.49, SD = 2.06         | M = 5.05, SD = 2.24  | Welch's $F_{(1,164.656)}=5.179$ , p <.05    |
| Support by company                                                            | M = 4.21, SD = 2.32         | M = 2.76, SD = 2.19  | Welch's $F_{(1,183.828)}=34.263$ , p <.001  |
| Earn miles                                                                    | -                           | M = 2.73, SD = 2.32  | -                                           |
| Never considered train travel                                                 | -                           | M = 4.04, SD = 2.33  | -                                           |

**Appendix B** Study 1, Mean, Standard deviation and ANOVA, Frequency of public transportation use and consideration of long-distance train travel

|                           | M    | SD    | ANOVA                                      |
|---------------------------|------|-------|--------------------------------------------|
| <i>Private travelers</i>  |      |       |                                            |
| Frequent                  | 5.68 | 1.876 | Welch's $F_{(2, 253.831)}=18.411, p =.000$ |
| Moderate                  | 5.12 | 2.079 |                                            |
| Infrequent                | 4.43 | 2.300 |                                            |
| <i>Business travelers</i> |      |       |                                            |
| Frequent                  | 5.47 | 2.048 | Welch's $F_{(2, 143.003)}=5.724, p =.004$  |
| Moderate                  | 5    | 2.173 |                                            |
| Infrequent                | 4.48 | 2.449 |                                            |

**Appendix C** Study 1, Games-Howell post-hoc test results, Frequency of public transportation use and consideration of long-distance train travel.

| Differences between frequent, moderate and infrequent public transportation users. | Mean difference | Std. error | <i>p</i> | 95% Confidence interval |             |
|------------------------------------------------------------------------------------|-----------------|------------|----------|-------------------------|-------------|
|                                                                                    |                 |            |          | Lower Bound             | Upper Bound |
| <i>Private travelers</i>                                                           |                 |            |          |                         |             |
| Moderate – infrequent users                                                        | 0.688*          | 0.258      | 0.023    | 0.080                   | 1.300       |
| Frequent – moderate users                                                          | 0.562*          | 0.162      | 0.002    | 0.180                   | 0.940       |
| Frequent – infrequent users                                                        | 1.250*          | 0.229      | 0.000    | 0.710                   | 1.790       |
| <i>Business travelers</i>                                                          |                 |            |          |                         |             |
| Moderate – infrequent users                                                        | 0.524           | 0.367      | 0.330    | -0.350                  | 1.390       |
| Frequent – moderate users                                                          | 0.468           | 0.229      | 0.104    | -0.070                  | 1.010       |
| Frequent – infrequent users                                                        | 0.992*          | 0.329      | 0.010    | 0.210                   | 1.780       |

\* The mean difference is significant.

**Appendix D** Study 1, Mean, Standard deviation and ANOVA, Travelcard ownership on consideration of long-distance train travel.

|                             | M    | SD    | ANOVA                                      |
|-----------------------------|------|-------|--------------------------------------------|
| <i>Private travelers</i>    |      |       |                                            |
| No Travelcard               | 4.65 | 2.293 | Welch's $F_{(5, 202.007)}=9.711$ , p =.000 |
| GA                          | 6.06 | 1.630 |                                            |
| Half fare (only)            | 5.52 | 1.947 |                                            |
| Half fare (+point-to-point) | 5.23 | 2.071 |                                            |
| Point-to-point              | 5.02 | 1.907 |                                            |
| Other                       | 5.97 | 1.850 |                                            |
| <i>Business travelers</i>   |      |       |                                            |
| No Travelcard               | 4.51 | 2.393 | Welch's $F_{(5, 117.471)}=4.214$ , p =.001 |
| GA                          | 5.64 | 1.884 |                                            |
| Half fare (only)            | 5.48 | 1.994 |                                            |
| Half fare (+point-to-point) | 5.10 | 2.290 |                                            |
| Point-to-point              | 4.53 | 2.273 |                                            |
| Other                       | 6    | 1.952 |                                            |

**Appendix E** Study 1, Games-Howell post hoc test results, travelcard ownership and consideration of long-distance train travel.

| Differences between<br>Travelcard types     | Mean<br>difference | Std.<br>Error | <i>p</i> | 95% Confidence<br>Interval |                |
|---------------------------------------------|--------------------|---------------|----------|----------------------------|----------------|
|                                             |                    |               |          | Lower<br>Bound             | Upper<br>Bound |
| <i>Private travelers</i>                    |                    |               |          |                            |                |
| No Travelcard - GA                          | -1.405*            | 0.221         | 0.000    | -2.04                      | -0.77          |
| No Travelcard - Half fare (only)            | -0.870*            | 0.205         | 0.000    | -1.46                      | -0.28          |
| No Travelcard - Half fare (+point-to-point) | -0.575             | 0.250         | 0.198    | -1.29                      | 0.14           |
| No Travelcard - Point-to-point              | -0.365             | 0.306         | 0.841    | -1.25                      | 0.52           |
| No Travelcard - other                       | -1.318*            | 0.364         | 0.008    | -2.39                      | -0.24          |
| <i>Business travelers</i>                   |                    |               |          |                            |                |
| No Travelcard - GA                          | -1.125*            | 0.329         | 0.010    | -2.07                      | -0.18          |
| No Travelcard - Half fare (only)            | -0.973*            | 0.285         | 0.010    | -1.79                      | -0.15          |
| No Travelcard - Half fare (+point-to-point) | -0.586             | 0.368         | 0.603    | -1.65                      | 0.47           |
| No Travelcard - Point-to-point              | -0.019             | 0.463         | 1.000    | -1.38                      | 1.34           |
| No Travelcard - Other                       | -1.489*            | 0.485         | 0.042    | -2.95                      | -0.03          |

\* The mean difference is significant.

**Appendix F** Comparison of the characteristics of the two independent samples used in Study 1 and Study 2

| Variables                   |                                        | Sample Study 1<br>(N=1021) | Sample Study 2<br>(N=48) | Swiss<br>Population |
|-----------------------------|----------------------------------------|----------------------------|--------------------------|---------------------|
| Gender                      | Female                                 | 51%                        | 50%                      | 51%                 |
|                             | Male                                   | 49%                        | 50%                      | 49%                 |
| Age                         | 15-19                                  | 6%                         | 0%                       | 6%                  |
|                             | 20-29                                  | 16%                        | 100%                     | 15%                 |
|                             | 30-44                                  | 25%                        | 0%                       | 25%                 |
|                             | 45-59                                  | 26%                        | 0%                       | 27%                 |
|                             | 60+                                    | 27%                        | 0%                       | 26%                 |
| Region<br>(excl.<br>Ticino) | Western Switzerl.<br>(French-speaking) | 25%                        | N/A                      | 25%                 |
|                             | Alps & Prealps                         | 24%                        | N/A                      | 24%                 |
|                             | Swiss Plateau West                     | 22%                        | N/A                      | 22%                 |
|                             | Swiss Plateau East                     | 29%                        | N/A                      | 29%                 |
| Political<br>Attitude       | Right-wing                             | 45%                        | N/A                      | 51%                 |
|                             | Center                                 | 27%                        | N/A                      | 23%                 |
|                             | Left-wing                              | 21%                        | N/A                      | 27%                 |
| Education                   | Low/medium                             | 58%                        | 0%                       | 56%                 |
|                             | High                                   | 42%                        | 100%                     | 44%                 |

## Paper 3

### How do we feel about flying?

Exploring the role of implicit associations with air travel in low-carbon travel mode choices<sup>1</sup>

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#### Abstract

Transitioning towards a more sustainable future of travel is central to achieving global climate goals. This study explores emotional antecedents of low-carbon mode choices for long-distance leisure travel. An implicit association test uncovers travelers' underlying psychological processes by measuring implicit associations with air compared to train travel. Most (75%) of N=412 respondents have either positive or negative implicit associations with air travel. Respondents with positive associations are more prone to take the plane for their long-distance continental trips. Those with negative associations are inclined to choose the train. We also show that, in contrast to environmental attitudes, implicit measures are strongly related to air and train travel intentions. Further investigation of implicit associations and emotions in the context of travel mode choices is thus desirable. Decision makers in the business and policy arena should go beyond conveying environmental aspects of travel mode choices by considering the important role of emotions.

**Keywords:** climate change, air travel, train travel, implicit association test, emotions.

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# 1 Introduction

Air travel presents a central challenge to limiting global warming to preferably 1.5 degrees Celsius by 2050 compared to pre-industrial levels (Gössling et al., 2009; Peeters, 2013; UNFCCC, 2015; Gössling & Humpe, 2020; Ivanova & Wood, 2020). Flying has been identified as one of the most carbon-intense travel-related activities (Lenzen et al., 2018). However, effective global policies to address the projected rapidly growing air travel demand are still missing (Lyle, 2018; Dubois et al., 2019). Social movements are increasingly raising awareness about this global challenge and are emphasizing the importance of changing flying behaviors, for example, by replacing air with low-carbon alternatives such as train travel (see, e.g., Fridays For Future, 2018; Flight Free World, 2021). Amid these developments, in early 2020, travel bans and lockdowns aimed at containing the spread of the COVID-19 pandemic have put an abrupt halt to established flying habits. They have temporarily hampered the global demand for air travel more than previous pandemics or economic shocks such as the financial crisis of 2008 (Abu-Rayash & Dincer, 2020; ATAG, 2020; Boin et al., 2020).

Shifting social norms and the COVID-19 outbreak create a high degree of uncertainty about what future travel patterns will look like. Reaching climate policy targets depends on a significant reduction of CO<sub>2</sub> emissions within the next decade (Rogelj et al., 2015; UNFCCC, 2015). Therefore, the current momentum may represent an opportunity to transition towards a more sustainable future of travel (e.g., Gössling, 2020; Gössling & Higham, 2020). Since effective technological solutions such as electric (Wright Electric, 2020) or hydrogen planes (Airbus, 2020) are not expected to enter the commercial market before 2030, limiting air travel emission growth will strongly rely on behavior change (Peeters, 2013). Specifically, preventing a quick return to pre-COVID-19 air travel growth rates will require avoiding and reducing air travel by rethinking travelers' decisions when it comes to their destination choices (Peeters, 2013; Gössling et al., 2015; Gössling & Higham, 2020) and travel mode choices (Dällenbach, 2020).

Prior literature focusing on air travel behavior has documented an attitude-behavior gap (McKercher et al., 2010; Higham et al., 2016; Alcock et al., 2017; Passafaro, 2020) as a key barrier to transitioning to a low-carbon travel future. Although travelers with environmentally friendly attitudes may feel guilty about their flying behavior they do not necessarily stop flying (Cohen et al., 2011). Also, recent studies suggest that

society's view on flying is changing (Cousse et al., 2020; Gössling et al., 2020). Social norms can be a powerful predictor of behavior change (Schultz et al., 2007), as observed in Sweden (Hoikkala & Magnusson, 2019). However, statistically significant evidence to propose that changing social norms have affected air travel behavior is still missing (Gössling et al., 2020).

Emotional aspects related to air travel may be one reason why the attitude-behavior gap persists. The emergence of “flights to nowhere” as a reaction to COVID-19 travel bans (see, e.g., Mzezewa, 2020a; Qantas, 2020) suggests that excitement about flying is a central factor driving air travel demand. It has been acknowledged, for example by Gössling et al. (2020), that air travel decisions, similar to everyday travel mode choices, are linked to affective and symbolic factors (Steg, 2005). Considerable attention is also given to the role of emotions in tourism experiences (Hosany, 2012; Hosany et al., 2015; Knobloch et al., 2017; Prayag et al., 2017; Hosany et al., 2020). But as Souche-Le Corvec and Zhao (2020) point out, emotions are given limited attention both when it comes to air travel behavior as well as in the field of transportation research as a whole. We contribute to closing this research gap by investigating people's emotional attachments with air travel.

To gain an in-depth understanding of the role of emotions in travel mode decisions, we employ implicit methods of inquiry alongside the traditionally used explicit methods of measuring stated preferences. Namely, we applied an implicit association test (IAT) to identify respondents' unconscious associations with air travel (Greenwald & Banaji, 1995; Greenwald et al., 1998). We integrated the IAT into a survey through which we collected data representative of the Swiss population ( $N = 421$ ). IAT has been successfully used to investigate decision-making across various contexts, including pro-environmental consumer choices and travel behavior (Chen & Chancellor, 2019; Ledesma et al., 2019).

By analyzing the emotional antecedents of travel mode choices, our research contributes to the literature on travel behavior, the field studying air travel choices in particular (e.g., Higham et al., 2014; Higham et al., 2019; Dällenbach, 2020), both thematically and methodologically. From the findings, we derive strategies to help industry stakeholders and policymakers navigate the sustainable transition of the travel sector and foster long-term behavior change towards low-carbon travel choices.

The paper is structured as follows. Section 2 reviews the literature on emotional and affective antecedents of travel mode choices and informs the study's methodological

approach. It also outlines the research objective and specifies the research questions. In Section 3, we describe the method and sample. Section 4 presents the results, while Section 5 discusses them and puts them in the broader context of existing research. Section 6 offers a conclusion and implications for further research, industry, and policymakers.

## **2 Literature review**

### **2.1 Emotional antecedents of travel mode choices**

Research increasingly points to the importance of emotions and affect in guiding behaviors (Epstein, 1994; Fredrickson, 2000; Loewenstein et al., 2001; Loewenstein & Lerner, 2003; Peters et al., 2006; Slovic et al., 2007; Lerner et al., 2015). Investigating the emotional factors may also help better understand the persisting gap between environmental attitudes and frequent air travel behavior. In the following, we review the literature that points to negative and positive emotional aspects of air travel behavior. Given the critical role of social norms in air travel behavior (Gössling, 2019; Gössling et al., 2020; Cousse et al., 2020), we distinguish between emotions that mainly have a social function and those that are elicited through the travel mode experience.

#### **2.1.1 Emotions and (evolving) social norms**

Self-conscious emotions (i.e., guilt, shame, pride, social anxiety, or embarrassment) are elicited based on how individuals think their behavior is evaluated by others (Leary, 2007, p.319). They have a social function in regulating interpersonal behavior (Leary, 2007). They can also act as a motivator to conform to social norms and moral standards (Scheff, 1988; Tangney et al., 2007).

Guilt and shame are increasingly discussed in the context of air travel. As for the former, past literature has indicated that people with environmentally friendly attitudes, who choose to fly, feel guilty about their behavior as their attitudes and behavior do not align (Cohen et al., 2011; Kroesen, 2013). This phenomenon can be explained by Festinger's (1957) cognitive dissonance theory. It suggests that the non-alignment of one's attitudes and behavior results in a feeling of discomfort, in this case, guilt (Festinger, 1957). This feeling motivates either behavior or attitude change in order to align attitudes and behavior again (Lavergne & Pelletier, 2016; Hanna & Adams, 2019). Guilt has also been investigated in the context of voluntary and integrated carbon offsets.

Kotchen (2009) argues that voluntary carbon offsets may reduce guilt and, in turn, encourage air travel. However, when it comes to integrated carbon offsets, Bösehans et al. (2020) suggest that carbon offsets do not reduce travelers' guilt levels about flying. With the rise of social movements since 2018, Swedish terms such as “flygskam” (flight shame) or “tågskryt” (train pride) have spread globally from Northern Europe (Hoikkala & Magnusson, 2019; Thornhill, 2019; Claeys, 2020b). Their increasing relevance resulted in a new discourse in research focusing on the role of shame in changing air travel behavior (Gössling et al., 2019; Claeys, 2020a; Gössling et al., 2020).

The two negatively valenced self-conscious emotions, guilt and shame, have an important distinction. People feel guilty if a specific action violates a standard, yet they feel ashamed if this violation is related to their character (Wicker et al., 1983; Leary, 2007). Claeys (2020a, 2020b) applies this distinction to flying. She points out that feeling guilty about flying would require that someone has acted unsustainably. In contrast to guilt, Claeys (2020b) argues that “green shame goes much deeper: it is the feeling that the choice you made is irreconcilable with your ideas about what it means to live a good life, a life with dignity.” As such, the flygskam (flight shame) movement aims at criticizing the air travel dependent lifestyles that have become entrenched in society over the past decades (Gössling et al., 2019). In most societies, being mobile is socially desirable and linked to social status (Urry, 2012). The rise of social media use among society made highly mobile lifestyles even more glamourized (Gössling & Stavrini, 2016). Oswald and Ernst (2020) found social media users likely have cosmopolitan social identities, which are directly linked to air travel. Furthermore, the entrance and growth of low-cost airlines contributed to the steep decrease in air travel costs over the past decades (Clewlow et al., 2014; European Commission, 2021), making it increasingly easy for people to adopt hypermobile lifestyles. Replacing the social norms that sustain frequent flying with new societal views has been identified as critical for behavior change (Gössling et al., 2020). Recent empirical insights from Switzerland and Germany confirm that social movements' growing importance is contributing to norm change. Thereby, Cousse et al. (2020) reveal that the majority of Swiss respondents evaluate air travel as too cheap. Similarly, Gössling et al. (2020) show that two-thirds of respondents would support the introduction of market mechanisms to increase the cost of flight tickets.

In contrast to “flygskam” (flight shame), the term “tågskryt” (train pride) has so far not been studied by researchers in relation to air travel behavior. While studies on travel

mode choices do not yet discuss specific positive emotions, past studies have identified flying as socially desirable. Specifically, Urry (2012) refers to the feeling of desire for flying and Cohen and Gössling (2015) show that travel and mobility have been glamourized in society - a perception that has been reinforced through media and air travel advertisements. These insights indicate that positive self-conscious emotions like pride (Leary, 2007) are at play. Pride is linked to self-esteem, which signals social status and regulates group acceptance (Leary et al., 1995; Brown & Marshall, 2001; Tracy & Robins, 2007). As status is related to frequent flying (Urry, 2012; Gössling & Stavrinidi, 2016), pride is likely closely linked to frequent flying lifestyles. With the change towards a society in which frequent travelers' lifestyles are criticized, pride and social status could become increasingly associated with signing a pledge not to fly (see Flight Free World, 2021) and taking the train instead of the plane.

### **2.1.2 Emotions related to the travel experience**

Emotional aspects of travel not only have a social dimension. They are also linked to the travel experience itself. Thereby, literature has mostly focused on the negative emotional experience of stress. Stress has been connected to traveling to a vacation destination in general (Zehrer & Crotts, 2012) and the air travel experience specifically (Bricker, 2005). Zhang et al. (2021) recently identified stress as a key challenge for sustaining air travelers' satisfaction. The high uncertainty about health risk exposure during the COVID-19 pandemic may likely contribute to the stress-factor of the air travel experience (LaMotte, 2020; Mzezewa, 2020b). However, most past studies analyzing affective aspects of travel mode choices have focused on daily commuter and leisure modes (Schaeffer et al., 1988; Gulian et al., 1990). These contributions find travel modes to be associated with different affective states. Some studies find car commuters to reveal significantly higher stress-levels than other mode users (Gatersleben & Uzzell, 2007; Wener & Evans, 2011). Walking and cycling can be more satisfying and relatively more exciting and relaxing than competing modes (Gatersleben & Uzzell, 2007; Friman et al., 2013). Thus, walking and cycling have often been identified as the best mode choice from an affective viewpoint (Gatersleben & Uzzell, 2007).

## 2.2 Implicit associations with air travel

Social psychology makes an important distinction between measuring conscious and unconscious mental processes (Greenwald & Banaji, 2017). Explicit or direct measures of inquiry are suitable if respondents are consciously aware of their assessment and associations with an object (Greenwald & Banaji, 1995; Greenwald & Banaji, 2017). Measuring affect via explicit evaluations on a scale from negative to positive, for example, is how risk researchers have traditionally measured whether individuals evaluate an object as positive or negative (Dohle et al., 2010; for an explicit measure of affect see e.g., Peters & Slovic, 1996). By contrast, implicit measures of inquiry can uncover automatic and unconscious psychological processes (Fazio & Olson, 2003; Carpenter et al., 2019). Research increasingly emphasizes the value of using implicit measures as their predictive validity in determining human behavior is superior to explicit measures, particularly for sensitive topics such as pro-environmental behavior that can suffer from social desirability bias (Van de Mortel, 2008; Greenwald et al., 2009; Goerres & Prinzen, 2012). As such, indirect means of inquiry have been proposed as a possible alternative way of exploring the attitude-behavior gap in the context of sustainable tourist behavior (Greenwald & Banaji, 2017; Passafaro, 2020).

In light of the observations that social movements are putting the morality of frequent air travel into question and that social norms associated with flying are evolving (Cousse et al., 2020; Gössling et al., 2020), we argue that air travel choices are socially sensitive. Employing indirect measures of inquiry is thus necessary to fully understand the determinants of air travel behavior while controlling for potential social desirability bias (Fisher, 1993).

## 2.3 Research objective and questions

This study aims to shed light on the emotional antecedents of travel mode decisions, with a specific focus on the role of implicit associations in mode preferences between plane and train for intercontinental and continental travels. Our literature review points to several positive and negative emotional associations that are connected to air travel behavior (Bricker, 2005; Urry, 2012) and daily travel mode choices (Schaeffer et al., 1988; Gulian et al., 1990; Steg, 2005; Gatersleben & Uzzell, 2007; Wener & Evans, 2011; Friman et al., 2013). It also emphasizes the importance of investigating implicit social cognition by indirect measures of inquiry to better understand decision-making,

especially in socially sensitive areas such as low-carbon travel mode choices (Fisher, 1993; Greenwald et al., 2009; Carpenter et al., 2019; Chen & Chancellor, 2019).

However, researchers have given only limited attention to the role of emotions, implicit affective evaluations in particular, for long-distance travel mode choices. To address this gap, we measure Swiss respondents' implicit affective associations with air compared to train travel. We thereby aim to answer the following research questions:

RQ1. What are the characteristics of respondents with negative and positive implicit associations with air travel?

RQ2. How do implicit associations with air travel relate to long-distance travel mode preferences?

RQ3. In comparison to environmental attitudes, how do implicit associations relate to travel mode preferences and future travel plans?

### **3 Methods**

#### **3.1 Sample**

As Gössling and Humpe (2020) point out, only 1% of the global population accounts for half of the global CO<sub>2</sub> emissions stemming from passenger air travel. Thus, when analyzing air travel decisions, it is especially relevant to focus on samples that significantly contribute to the global share of air travel emissions. Switzerland, the focus of this study, ranks among the top ten countries with the highest share of national emissions stemming from air travel (Gössling & Humpe, 2020). Also, more than half of the Swiss population still underestimates the impact of flying on the country's carbon footprint (Cousse et al., 2020) despite the growing importance of movements such as #FridaysForFuture (Fridays For Future, 2018; ZHAW, 2019).

Our sample consists of  $N = 421$  respondents and is representative of the Swiss population in terms of age and gender (see Appendix A for our sample's socio-demographic characteristics). Respondents were recruited by the market research agency Innofact AG. We conducted the online survey in one language (in German) and thereby followed Chassot et al. (2015), who ran their IAT in a single language to avoid confounding effects from translation issues, despite analyzing Switzerland as a multilingual country (FSO, 2018). We screened out French- and Italian-speaking

respondents and focused on the German-speakers, representing 62.2% of the overall Swiss population (FSO, 2018).

### 3.2 Study design

We conducted the online study in October 2020. The study was set-up in the survey software tool Qualtrics and included the implicit association test (IAT) followed by explicit measures of inquiry. We developed the IAT in the IATgen tool (Carpenter et al., 2019; Iatgen, 2020). The tool allowed us to generate an IAT compatible with Qualtrics and analyze the data directly in its interface.

After an introduction to the study, respondents proceeded to the IAT. The IAT measures respondents' implicit association between a concept and an attribute through an assignment task. Stimuli representing the concept (such as *airport* and *pilot* for the concept *air travel*, as used in our study) or the attribute (such as *exciting* and *interesting* for the attribute *positive*) appear in the middle of the screen (Greenwald et al., 1998). The task instructs participants to use given keyboard keys to assign the stimuli to the matching pair of a concept and an attribute appearing on the right- or the left-hand side of the screen. The strength of the implicit association is tested in comparison to the mental opposite, in our case the concept *train travel* (represented by stimuli such as *train station* and *train tracks*) and the attribute *negative* (such as *annoying* and *stressful*) (Greenwald et al., 1998; Nosek et al., 2002b). The test assumes that it is easier for participants to assign the stimuli to the correct concept and attribute if the pairs appearing on the screen are compatible with their internal beliefs. These assignments are expected to be quicker than in the incompatible condition (Greenwald et al., 1998; Nosek et al., 2002b).

The differences in speed in which the assignments between compatible and incompatible pairs are made result in the standardized difference score, the so-called d-score, the primary output of the IAT (Nosek et al., 2002a; Pogacar et al., 2019). The higher the d-score, the stronger the association; positive scores indicate an association in the hypothesized direction, negative in the opposite one. Cohen (1988) divides the score into categories that indicate little or no association<sup>4</sup> (score of  $|0 - 0.15|$ ), slight ( $|0.15 - 0.35|$ ), moderate ( $|0.35 - 0.65|$ ), and strong association ( $|0.65|$  and higher). To prevent biases resulting from the order in which the compatible and incompatible pairs

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<sup>4</sup> For the label "little or no association" we follow Greenwald et al. (2003).

appear, the test randomly assigns respondents to one of four permutations, which differ in their assignment order (Carpenter et al., 2019).

Following the method proposed by Greenwald et al. (1998), the test entails 180 assignment trials divided into 7 blocks that consist of trial rounds (1, 2 and 5) and critical blocks incorporated into the final data analysis (rounds 3, 4 and 6, 7, which contrast compatible and incompatible pairs). For the illustrations of the IAT task with the concepts and attributes used in the present study, see Appendix B – C.

After finalizing the IAT, respondents were asked several explicit self-reported questions, mainly using single, multiple-choice, and 7-point Likert scale type of questions. Based on these questions, we measured our independent, dependent, and control variables.

### 3.3 Measures

#### 3.3.1 Implicit associations with air travel

The selection of the stimuli representing the IAT's concepts and attributes is critical for the reliability of the generated data. We applied a mixed-method research approach to determine the final stimuli list per category. Consulting other studies in the field and methodological literature, we saw that the stimuli range from 3 to 10 (Greenwald et al., 1998; Nosek et al., 2002b); their most common number is between 4 and 6 (Project Implicit, 2011; Pogacar et al., 2019). We proceeded with searching for the appropriate terms for each concept. We first consulted the relevant literature to identify the most commonly associated terms relative to each category. For the verbal stimuli representing the attributes *positive* and *negative*, we built on the terminology used by Huijts (2018) and Steg (2005), who analyzed emotional dimensions of energy and travel mode choices, respectively. For the concepts *air travel* and *train travel*, we also extensively built on our pre-existing knowledge, excluding terms potentially applicable for both travel modes (such as *steward/stewardess* or *passenger*). Pre-selected stimuli were pre-tested by 15 expert participants in a qualitative discussion setting, upon which final adjustments to the stimuli list were undertaken. This mixed-method approach resulted in a list of 5 stimuli representing each category (see Table 1). Note that the German translation of the word *departure* is a term specifically representing a train's departure (*Abfahrt*).

**Table 1** IAT set-up: List of stimuli representing tested concepts and attributes.

| Concepts     | Stimuli                                                     |
|--------------|-------------------------------------------------------------|
| Air travel   | Airport, pilot, plane, take-off, terminal                   |
| Train travel | Departure, train, train driver, train station, train tracks |
| Attributes   | Stimuli                                                     |
| Positive     | Exciting, lively, inspiring, interesting, thrilling         |
| Negative     | Annoying, disturbing, irritating, outrageous, stressful     |

### 3.3.2 Explicit measures

We included several psychological self-reported questions to measure our independent, control (see Section 3.3.2.1) and dependent variables (see Section 3.3.2.2), which we outline in the following.

#### 3.3.2.1 Psychological and socio-demographic variables

Explicit questions measuring independent and control variables were mainly designed to investigate the characteristics of respondents with positive, negative, and little or no associations with air travel. They consisted of the explicit evaluation of the air and train travel experience, considerations of travel safety in the COVID-19 pandemic context, environmental attitudes, perceptions of air travel's environmental friendliness, and past behavior. Except for past behavior, psychological measures were asked on a 7-point Likert scale with the endings labeled with the two extremes.

Socio-demographic variables included age, gender (male/female), and political orientation (green party voters vs. all other voters).

##### 3.3.2.1.1 *Feelings of stress vs. excitement towards air and train travel*

In addition to measuring implicit associations with air compared to train travel, we asked respondents to explicitly evaluate air and train travel. Respondents ranked both travel modes from “(1) – stressful” to “(7) – exciting” on a 7-point Likert scale, before the outbreak of the COVID-19 pandemic and in the current context. We provided respondents an opt-out option since some may, for example, not travel by plane or train long-distance in general or since the outbreak of the pandemic.

### *3.3.2.1.2 Perceptions about travel safety in the COVID-19 pandemic*

As we collected our data in October 2020, it was influenced by the COVID-19 pandemic. To consider this important contextual factor, we asked about the perceived safety of air and train travel at the moment. We specifically requested that respondents indicate their agreement with two statements on a 7-point Likert scale ranging from “(1) - I totally disagree” to “(7) - I totally agree”. The statements were: “At the moment I would feel safe in a plane” and “At the moment I would feel safe in a train (international long-distance trips).” Again, we provided respondents with an opt-out option.

### *3.3.2.1.3 Environmental attitudes and perceptions about air travel’s environmental friendliness*

Given the attention that environmental attitudes have received in previous literature focusing on air travel decisions (Barr et al., 2010; Higham et al., 2016; Alcock et al., 2017), we included a general measure of respondents’ attitudes towards environmental consumer behavior. We used a 6-item GREEN scale, a scale of green consumption developed by Haws et al. (2014), that controls for the environmental values as expressed in consumer purchase behavior. The scale’s reliability is proven by its high Cronbach alpha (0.926) and its broad applicability in the field (Maniatis, 2016; Reeck et al., 2018).

Additionally, we measured respondents’ perceptions about air travel’s environmental friendliness by asking them to rate how environmentally friendly different transport options, including car, train, bus, cruise ship, and plane, are. The endpoints of the 7-point Likert scale were “(1) - environmentally unfriendly” and “(7) - environmentally friendly”.

### *3.3.2.1.4 Past behavior*

Prior literature has highlighted the importance of familiarity in the context of mode choices between air and train travel (Bieger & Laesser, 2004; Dällenbach, 2020). As such, we also asked respondents about their travel mode choices for private purposes in 2019. Specifically, we included a question about how many private round trips (minimum distance of 300 km per one-way trip) respondents took in 2019 by different transportation means, including car, bus, plane for trips within Europe, plane for intercontinental trips, train and bike. In contrast to the other psychological measures, we offered respondents six answer options, namely 0, 1, 2, 3-5, 6-10, 10+ trips, to indicate the number of trips for every travel mode. For the data analysis, we categorized

respondents into infrequent (0 trips in 2019), moderate (1-2 trips in 2019), and frequent (3+ trips in 2019) travelers, separately for each transportation mean, train and plane (continental and intercontinental trips).

### 3.3.2.2 Future travel intentions and travel mode preferences

Our two main dependent variables are 1) future continental train, continental and intercontinental air travel intentions, and 2) travel mode preferences between train and plane within Europe. In both cases, we asked respondents about their future travel plans and preferences in a post-COVID-19 pandemic era. To grasp the full scope of future travel mode intentions, we asked respondents to indicate the percentage of trips they plan to make post-COVID-19 by individual means of transport, i.e., car, bus, train, plane (continental), plane (intercontinental), and bicycle; the overall share had to sum to 100%.

We also asked respondents more specifically about their travel mode preferences regarding 10 different European destinations, including Amsterdam, Barcelona, Berlin, Budapest, Lisbon, London, Milan, Oslo, Paris, and Vienna. We chose these destinations to reflect a wide range in terms of travel time, distance, and geographical location (East, West, South, and North from Switzerland). Answer options included car, bus, train, plane, and the decision not to visit the respective destination.

## 3.4 Data analysis

We used the IATgen tool to calculate the d-score for individual respondents and the final sample (Carpenter et al., 2019). Out of the total sample  $N = 421$ , the tool excluded  $N = 9$  participants with incomplete, too slow, or too speedy answers (the so-called “button mashing” when respondents answer the exercise without paying attention) (Pogacar et al., 2019). The final sample for our data analysis was thus  $N = 412$ . We incorporated the d-score of the final sample to the other data generated by the online study and analyzed it with the SPSS software. We categorized respondents based on their d-score into three groups with positive (d-score higher than 0.15), little or no (-0.15 to 0.15), and negative (d-score lower than -0.15) implicit air travel associations. Subsequently, we used chi-square tests and one-way ANOVAs to investigate differences between the three groups regarding their socio-demographic characteristics and psychological variables. In addition, paired sample t-tests were used to compare the relative preferences of train and air travel among the three groups. These analyses

allowed us to gain insights into the antecedents of implicit air travel associations. In a third step, we applied a multiple regression to investigate the relationship between implicit associations with air travel and future travel intentions while controlling for environmental attitudes, past behavior, age, gender, and political attitudes. Finally, we analyzed travel mode preferences between train and plane for 10 specific destinations in Europe, also based on implicit associations with air travel.

## **4 Results**

### **4.1 Implicit associations with air travel**

The IAT results reveal that individual participants within our sample ( $N = 412$ ) express highly differentiated feelings towards air travel that range from strongly negative (d-scores of up to  $-1.19$ ) to strongly positive (d-score of  $1.25$ ) implicit associations with air travel. Thereby, only a minority of respondents ( $N=102$ , 24.8% of the final sample) has little or no implicit associations with air travel (d-scores between  $-0.15$  and  $0.15$ ). In contrast, the large majority (75.2%) reveals strong (d-scores higher than  $0.65$  and lower than  $-0.65$ ) and rather strong (d-scores between  $0.15$  and  $0.65$  or  $-0.15$  and  $-0.65$ , respectively) implicit associations. The share of respondents with a (rather) strong positive implicit air travel association (d-score higher than  $0.15$ ) is somewhat higher ( $N=179$ ; 43.4% of respondents) than of those with a (rather) strong negative implicit association (d-score smaller than  $-0.15$ ;  $N=131$ , which represents 31.8% of respondents) (see Figure 1).

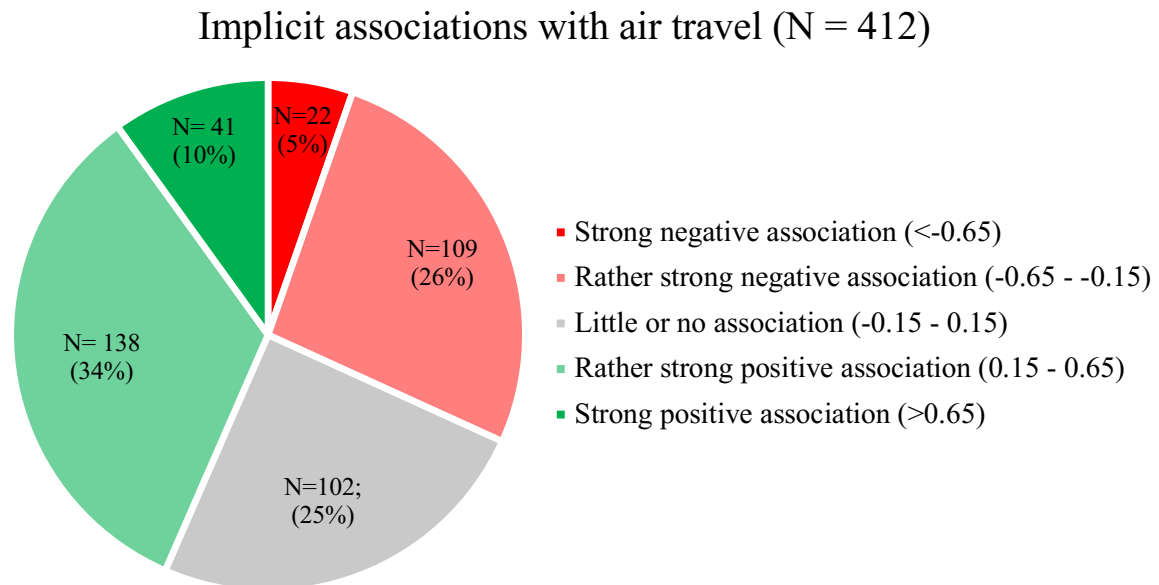


**Figure 1** Distribution of implicit associations with air relative to train travel among the final sample (N=412), individual respondent groups (i.e., respondents with positive (N=179; 43.4%), negative (N=131; 31.8%) and little or no (N=102; 24.8%) implicit associations with air travel).

## 4.2 Individuals' characteristics based on their implicit air travel associations

### 4.2.1 Differences in feelings of stress vs. excitement

We first investigated whether our IAT results are related to explicit emotional associations with air ( $n = 384$ ,  $M = 4.81$ ,  $SD = 1.78$ ,  $Min = 1$ ,  $Max = 7$ ) and train travel ( $n = 384$ ,  $M = 4.77$ ,  $SD = 1.55$ ,  $Min = 1$ ,  $Max = 7$ ). Note that we focused our analysis on respondents' ranking of the pre-pandemic measure ranging from "(1) – stressful" to "(7) – exciting". Comparing respondents' self-reported emotions related to air and train travel based on paired sample t-tests shows the following (see Appendix D). Respondents with positive implicit air travel associations find air travel ( $M = 4.91$ ,  $SD = 1.82$ ) significantly more exciting (compared to stressful) than train travel ( $M = 4.58$ ,  $SD = 1.52$ ;  $t(166) = 2.071$ ,  $p = 0.040$ ). In contrast, those with negative implicit associations find air travel ( $M = 4.58$ ,  $SD = 1.73$ ) significantly less exciting (compared to stressful) than train travel ( $M = 5.03$ ,  $SD = 1.55$ ;  $t(116) = -2.770$ ,  $p = 0.007$ ). Air and train travel are similarly exciting to respondents with little or no implicit associations with air travel (*explicit emotional associations with air travel*:  $M = 4.91$ ,  $SD = 1.75$ ; and *with train travel*:  $M = 4.77$ ,  $SD = 1.58$ ;  $t(99) = 0.625$ ,  $p = 0.533$ ). The results for the

explicit measure of emotions linked to the train and air travel experience are thus comparable to what we find in our IAT, which further proves the reliability of the chosen measures.

#### 4.2.2 Differences in perceptions about travel safety in the COVID-19 pandemic

Implicit associations with air travel may also be related to the perceived safety of air ( $n = 383$ ,  $M = 3.91$ ,  $SD = 2.05$ ,  $Min = 1$ ,  $Max = 7$ ) and train travel ( $n = 383$ ,  $M = 4.19$ ,  $SD = 1.96$ ,  $Min = 1$ ,  $Max = 7$ ) in the context of the COVID-19 pandemic. Paired sample t-tests (see Appendix D) reveal a significantly lower level of perceived air travel safety compared to the perceived train travel safety for respondents with negative implicit air travel associations (*perceived air travel safety*:  $M = 3.63$ ,  $SD = 2.02$ ; *perceived train travel safety*:  $M = 4.39$ ,  $SD = 1.95$ ;  $t(122) = -4.535$ ,  $p < 0.001$ ). Those with little or no (*perceived air travel safety*:  $M = 4.32$ ,  $SD = 1.97$ ; *perceived train travel safety*:  $M = 4.39$ ,  $SD = 1.99$ ;  $t(94) = -0.374$ ,  $p = 0.709$ ) and positive implicit associations (*perceived air travel safety*:  $M = 3.88$ ,  $SD = 2.08$ ; *perceived train travel safety*:  $M = 3.93$ ,  $SD = 1.93$ ;  $t(164) = -0.354$ ,  $p = 0.724$ ) did not reveal any differences when it comes to the perceived safety of air compared to train travel in the COVID-19 context.

#### 4.2.3 Differences in environmental attitudes and socio-demographic factors

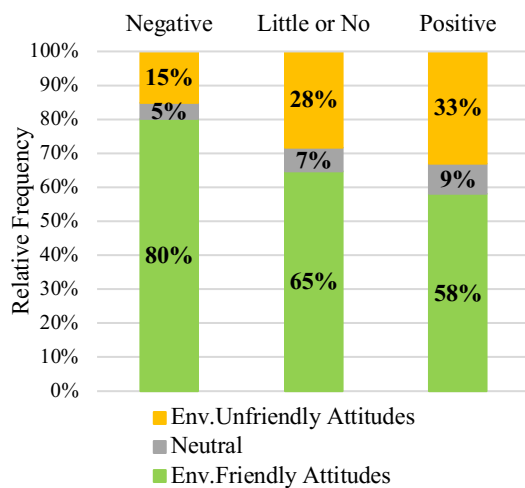
We conducted crosstab analyses (see Figure 2) and performed chi-square tests and one-way ANOVAs (see Appendix E – F) to determine whether the three groups, i.e., the respondents with negative, positive, and little or no implicit associations with air travel, differ in terms of their environmental attitudes, perceptions about air travel's environmental friendliness and socio-demographic characteristics.

For the Pearson chi-square tests, we categorized respondents into three groups for the case of perceptions about air travel's environmental friendliness and environmental attitudes. Scale points 1-3 resulted in "perceived environmental unfriendliness of air travel", scale point 4 in "neutral", and scale points 5-7 in "perceived environmental friendliness of air travel". Following the same cut-off points, we also formed three groups of "environmentally friendly", "neutral", and "environmentally unfriendly respondents".

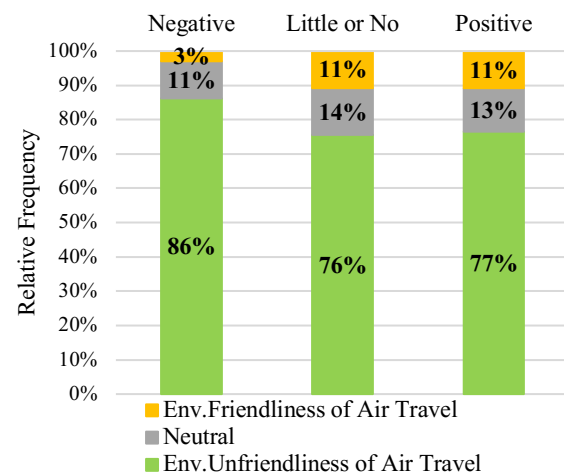
Pearson chi-square test results show significant associations between our implicit measure of affect and the following variables: environmental attitudes ( $\chi^2(4) = 16.931$ ,  $p = 0.002$ ), gender ( $\chi^2(2) = 9.492$ ,  $p = 0.009$ ) and political orientation ( $\chi^2(2) = 8.894$ ,  $p = 0.012$ ). In contrast, we did not find a significant association for the case of perceived

environmental friendliness of air travel ( $\chi^2(4) = 7.666, p = 0.105$ ) and age ( $\chi^2(10) = 10.681, p = 0.383$ ). Bonferroni adjusted post hoc z-tests reveal that compared to respondents with positive implicit air travel associations, those with negative ones are more likely environmentally friendly ( $p < 0.001$ ), green party voters ( $p = 0.009$ ), and female ( $p = 0.012$ ). We find similar but less pronounced differences when comparing respondents with negative and little or no implicit associations. The former are again more likely environmentally friendly ( $p = 0.024$ ) and female ( $p = 0.049$ ), yet not green party voters ( $p = 0.818$ ). Respondents with positive and little or no associations did not reveal differences.

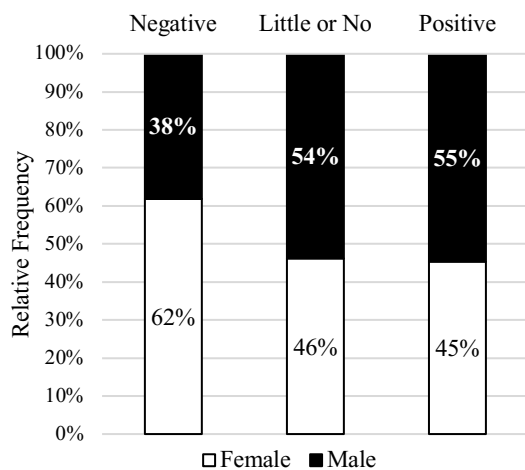
Environmental attitudes (N = 412)



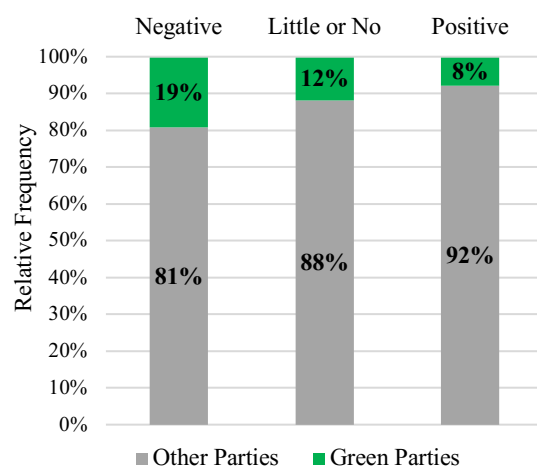
Perceived env. friendliness of air travel (N = 412)



Gender (N = 412)



Political orientation (N = 412)



Age (N = 412)

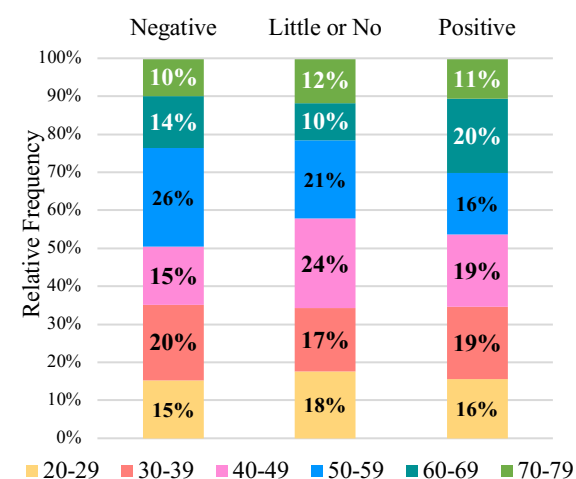


**Figure 2** Characteristics of respondents with positive, little or no, and negative implicit air travel associations

To compare the groups in terms of their environmental attitudes and perceived environmental friendliness of air travel, we additionally conducted two one-way ANOVAs, for which we used the 7-point Likert scale. One-way ANOVAs not only revealed significant differences for environmental attitudes ( $F(2, 409) = 12.95, p < 0.001$ ), but also for perceptions about air travel's environmental friendliness<sup>5</sup> (Welch's  $F(2, 242.66) = 5.52, p = 0.005$ ). For environmental attitudes ( $M = 4.63, SD = 1.35, \text{Min} = 1, \text{Max} = 7$ ), a Bonferroni adjusted post hoc test revealed that respondents with negative implicit air travel associations ( $M = 5.08, SD = 1.27$ ) uphold significantly stronger environmentally friendly attitudes than respondents with positive ( $M = 4.31, SD = 1.50; p < 0.001$ ) and little or no implicit air travel associations ( $M = 4.61, SD = 1.31; p = 0.022$ ). For perceptions about air travel's environmental friendliness ( $M = 2.35, SD = 1.45, \text{Min} = 1, \text{Max} = 7$ ), the post hoc test with Games Howell corrections revealed that those with negative implicit associations ( $M = 2.03, SD = 1.25$ ) perceive air travel as significantly more environmentally unfriendly than those with positive ( $M = 2.50, SD = 1.50; p = 0.008$ ) and little or no implicit associations ( $M = 2.50, SD = 1.51; p = 0.033$ ).

Respondents with little or no and positive implicit air travel associations seem to be rather similar regarding socio-demographic and attitudinal characteristics. Post hoc tests for the one-way ANOVAs also did not reveal statistically significant differences between these two groups.

### 4.3 Implicit associations and future travel intentions

Next, we investigated the relationship between implicit associations with air travel and future travel plans. To do so, we conducted three one-way ANOVAs to test the differences among respondents with positive, little or no, and negative implicit air travel associations regarding their air and train travel plans (see Figure 3)<sup>6</sup>. For the case of intercontinental air travel intentions, the results did not reveal significant differences among the three groups (Welch's  $F(2, 241.58) = 0.994, p = 0.372$ ). However, the groups significantly differ when it comes to continental air (Welch's  $F(2, 251.11) = 9.236, p < 0.001$ ) and train travel intentions (Welch's  $F(2, 222.53) = 9.590, p < 0.001$ ). Concretely, post hoc test results with Games-Howell corrections (see Appendix G) show that

<sup>5</sup> Levene's test of homogeneity of variances was significant for perceptions about air travel's environmental friendliness ( $p = 0.012$ ), which is why we report Welch's tests and post hoc tests with Games Howell corrections.

<sup>6</sup> Levene's test of homogeneity of variances was significant for the case of future travel intentions by train ( $p < 0.001$ ) and continental air travel ( $p = 0.013$ ). Thus, we report the results of robust tests of equality of means.

respondents with positive implicit air travel associations ( $M = 29.63$ ,  $SD = 27.15$ ,  $Min = 0$ ,  $Max = 100$ ) intend to travel by plane within Europe significantly more than respondents with negative ( $M = 17.38$ ,  $SD = 23.05$ ;  $p < 0.001$ ) and little or no implicit air travel associations ( $M = 22.27$ ,  $SD = 23.58$ ;  $p = 0.048$ ). Regarding continental train travel, respondents with positive implicit air travel associations ( $M = 12.74$ ,  $SD = 18.05$ ) intend to travel significantly less by train in the future than respondents with negative ( $M = 22.79$ ,  $SD = 26.40$ ,  $p = 0.001$ ) and little or no ( $M = 20.97$ ,  $SD = 22.41$ ,  $p = 0.005$ ) implicit associations with air travel.

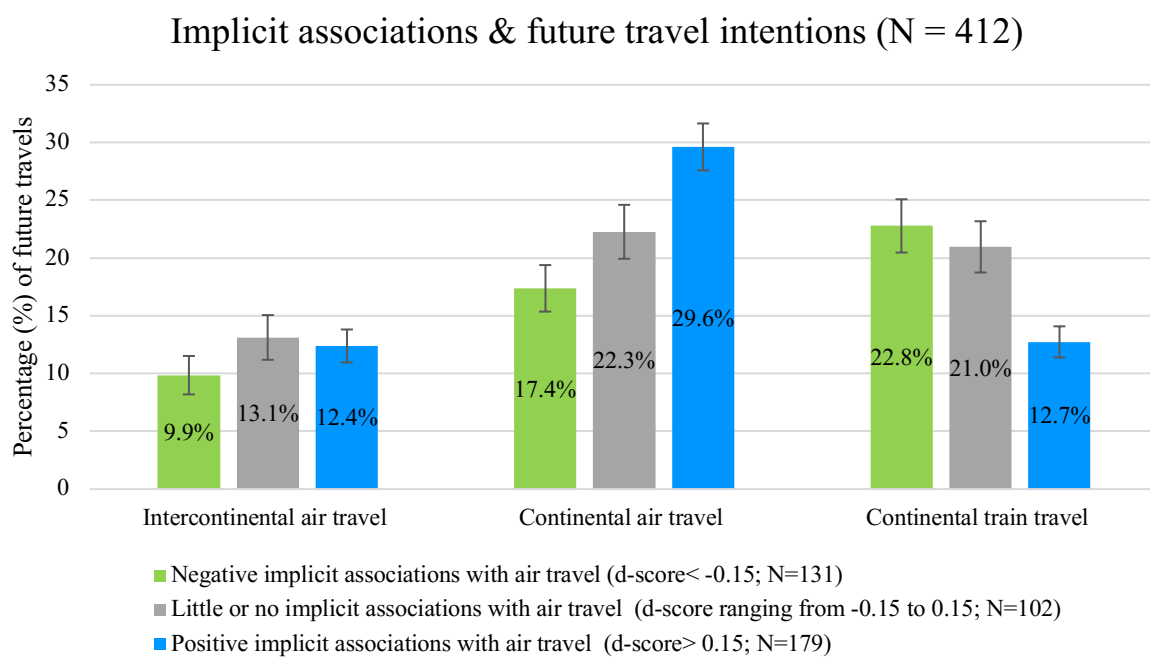


**Figure 3** Implicit associations with air travel and future travel intentions.

We also investigated the effect of implicit associations with air travel on future air and train travel intentions in multivariate models that accounted for environmental attitudes, past behavior, and socio-demographic characteristics. The three models differ in their dependent variable, being either future continental air travel (Model 1), intercontinental air travel (Model 2), and continental train travel intentions (Model 3). All multiple linear regression models on the three dependent variables were significant (see Appendix H – J).

Model 1 on the dependent variable future continental air travel intentions accounts for 20.4% of variance ( $F(9, 402) = 11.442$ ,  $p < 0.001$ ). Model 1 confirms that when controlling for all other variables, implicit associations still have a significant effect on

respondents' future continental air travel plans. Concretely, respondents with negative ( $B = -11.48, p < 0.001$ ) and little or no implicit air travel associations ( $B = -9.07, p = 0.002$ ) plan to fly significantly less within Europe than those with positive implicit associations. Thereby, the share of continental air travel plans is, on average, 11.48 percentage points lower for respondents with negative compared to respondents with positive implicit associations with air travel. Apart from the results for our main variable of interest, Model 1 also revealed statistically significant differences for past continental air travel behavior, namely between frequent (3+ trips in 2019) compared to moderate (1-2 trips in 2019) and infrequent (0 trips in 2019) continental air travelers. Infrequent ( $B = -28.16, p < 0.001$ ) and moderate ( $B = -14.35, p < 0.001$ ) continental air travelers plan for a significantly lower share of continental air travel than frequent continental air travelers. None of the other variables revealed a significant effect on future continental air travel intentions.

Model 2 focusing on intercontinental air travel plans ( $F(9, 402) = 11.662, p < 0.001$ ) explained 20.7% of the total variance. This model did not identify significant differences between respondents with negative, positive, or little or no implicit air travel associations. Past intercontinental air travel behavior is the only significant variable in Model 2, whereby infrequent intercontinental air travelers ( $B = -16.41, p < 0.001$ ) reveal a significantly lower share of intercontinental air travel plans than frequent intercontinental air travelers.

Model 3 with the dependent variable future continental train travel intentions ( $F(9, 402) = 12.101, p < 0.001$ ) accounted for 21.3% of the overall variance. This model found respondents with negative implicit associations with air travel to plan for a significantly higher share of train travel than those with positive implicit air travel associations ( $B = 5.97; p = 0.014$ ). There is, however, no significant difference between respondents with little or no and those with positive or negative implicit associations with air travel. Furthermore, future train travel intentions are also influenced by political orientation. Green party voters' share of future train travel is ( $B = 15.06; p < 0.001$ ), on average, 15 percentage points higher than other party voters' share of future train travel.

The three multiple regression models confirm that, when accounting for control variables, the difference between respondents with negative and those with positive implicit associations with air travel is significant for continental air travel and train travel; it is not significant for the case of intercontinental air travel. At the same time, the regression models reveal that environmental attitudes do not seem to be a significant

predictor of continental train, continental or intercontinental air travel plans, suggesting that implicit associations are a better predictor of future travel intentions.

#### 4.4 Travel mode preferences for European destinations

Descriptive results for travel mode choices for ten European destinations show that the preference for air travel increases with the distance to the destination (see Figure 4). Also, over 50% of respondents prefer air travel to seven out of ten destinations, while a majority of respondents prefer the train to only one destination.

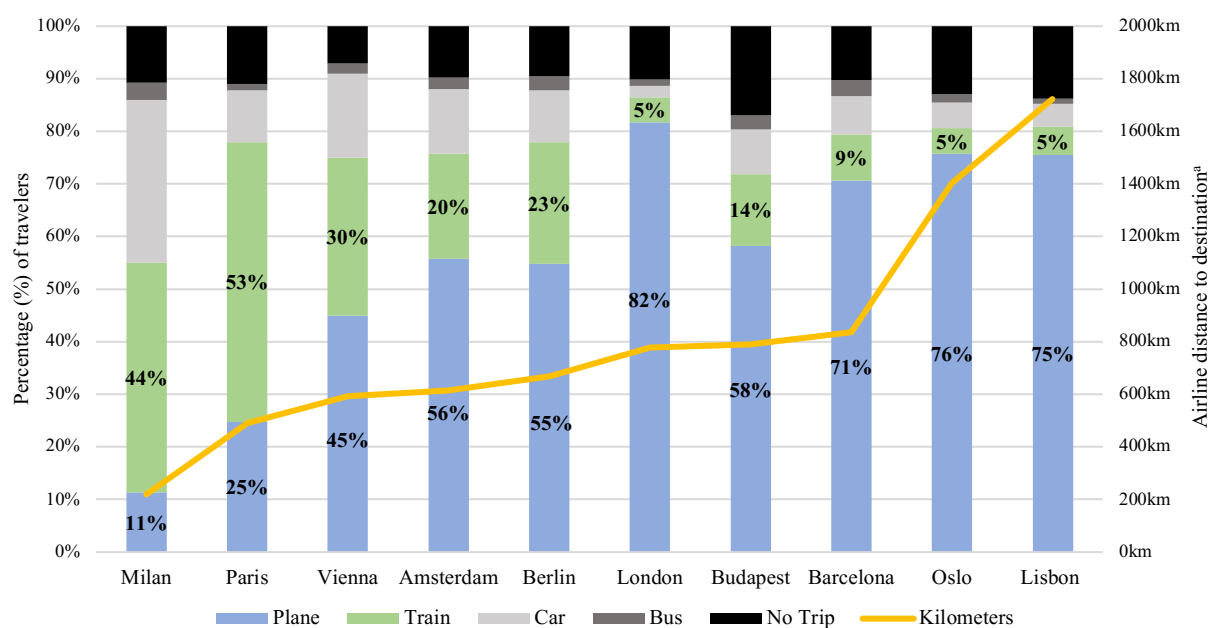


**Figure 4** European destinations: travel mode preferences of the final sample (N=412).

<sup>a</sup> Airline distances to the European destinations from Zurich indicated in km based on railcc (2021). Zurich was chosen as a starting point since it operates the major international airport in the German part and Switzerland as such.

Figure 5 shows how preferences for train vs. air travel to those destinations interact with implicit associations. The main aim was to investigate whether the different travel mode preferences of respondents with positive and negative implicit air travel associations hold when it comes to these specific destinations. Respondents who prefer the bus, car, or do not intend to travel to the destination were excluded from the analysis.

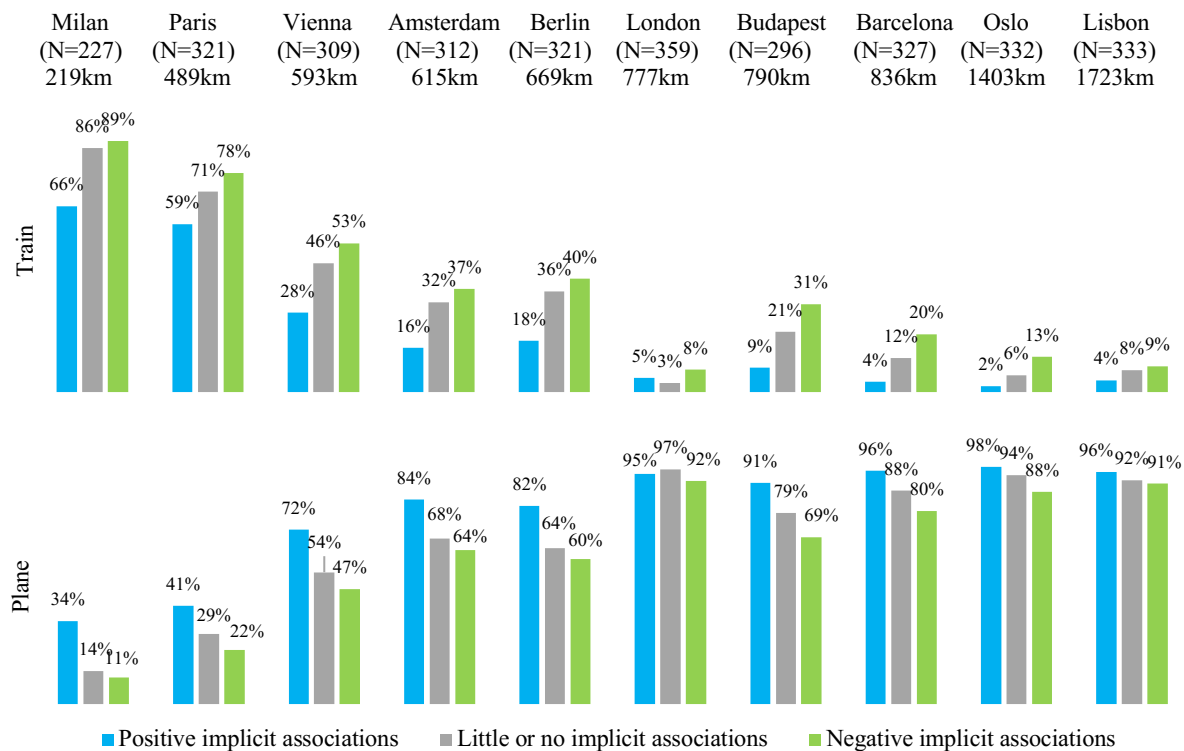


**Figure 5** Differences between groups based on implicit association with air travel by mode preferences between train and plane for the 10 selected destinations.

Pearson's chi-square tests revealed significant differences between respondents with positive and those with negative or little or no implicit associations for six destinations, including Milan ( $\chi^2(2) = 15.836, p < 0.001$ ), Vienna ( $\chi^2(2) = 15.220, p < 0.001$ ), Amsterdam ( $\chi^2(2) = 14.163, p = 0.001$ ), Berlin ( $\chi^2(2) = 15.229, p < 0.001$ ), Budapest ( $\chi^2(2) = 17.532, p < 0.001$ ), and Barcelona ( $\chi^2(2) = 16.495, p < 0.001$ ). For two additional destinations, Paris ( $\chi^2(2) = 9.057, p = 0.011$ ) and Oslo ( $\chi^2(2) = 11.210, p < 0.004$ ), the differences were significant between respondents with positive and negative implicit associations. London ( $\chi^2(2) = 2.246, p = 0.325$ ) and Lisbon ( $\chi^2(2) = 2.475, p = 0.290$ ) are the only destinations for which chi-square tests did not reveal significant differences among the three groups.

We also conducted Pearson chi-square tests to compare the above results with travel mode preferences of respondents with environmentally friendly, neutral and environmentally unfriendly attitudes. In this case, our results revealed significant differences between respondents with environmentally friendly and those with neutral or environmentally unfriendly attitudes for the destinations Milan ( $\chi^2(2) = 14.102, p = 0.001$ ) and Vienna ( $\chi^2(2) = 19.305, p < 0.001$ ). For four additional destinations, namely Paris ( $\chi^2(2) = 10.463, p = 0.005$ ), Amsterdam ( $\chi^2(2) = 8.506, p = 0.014$ ), Budapest ( $\chi^2(2)$

= 8.605,  $p = 0.014$ ) and Barcelona ( $\chi^2(2) = 10.512$ ,  $p = 0.005$ ), we found significant differences between respondents with environmentally friendly and environmentally unfriendly attitudes, whereby neutrals did not significantly differ from these two groups. Chi-square tests did not reveal differences among the three groups for four destinations, namely Berlin ( $\chi^2(2) = 4.245$ ,  $p = 0.120$ ), London ( $\chi^2(2) = 2.905$ ,  $p = 0.234$ ), Oslo ( $\chi^2(2) = 0.442$ ,  $p = 0.802$ ), and Lisbon ( $\chi^2(2) = 1.810$ ,  $p = 0.404$ ). As such, we find implicit associations to significantly predict travel mode preferences for eight out of ten European destinations; this number, however, drops to six for the case of environmental attitudes.

## 5 Discussion

### 5.1 Differences in individuals with positive and negative implicit air travel associations

The IAT allowed to uncover respondents' affective implicit associations with air as opposed to train travel. 75.2% of respondents have strong and rather strong implicit associations with air travel. Out of these participants, more have positive associations (43.4%) compared to 31.8% of the sample with negative implicit air travel associations. These results are a first indication that at the individual level implicit associations with air travel mirror the polarization between established and newly emerging flying norms within society (see Gössling et al., 2020). A closer look at the differences between individuals with negative and positive implicit associations with air travel provided further insights (see RQ1). For one, respondents with positive implicit associations with air travel explicitly evaluate flying as significantly more exciting (as opposed to stressful) than train travel, while respondents with negative implicit associations regard train travel as more exciting than air travel. Secondly, respondents with negative implicit associations perceive train travel as significantly safer than air travel in the COVID-19 pandemic context, while those with positive implicit associations perceive air and train travel as similarly safe. Finally, respondents with negative implicit associations with air travel are significantly more likely to be green party voters, environmentally friendly and to perceive air travel as less environmentally friendly than respondents with positive implicit associations.

These results provide further evidence to suggest that positive implicit associations with air travel are related to the excitement that air travel has symbolized over the past

decades and still seems to represent today (see also Urry, 2012; Gössling & Stavrinidi, 2016; Gössling, 2019; Oswald & Ernst, 2020). Simultaneously, societal norms are shifting towards air travel being considered as undesirable due to environmental reasons (Gössling et al., 2020; Cousse et al., 2020). This latter fact is reflected in the responses of those with negative implicit associations who are more environmentally friendly, more likely green party voters and also perceive air travel as more environmentally unfriendly. Our results also indicate that the COVID-19 pandemic contributes to the stress-factor of the air travel experience, but only for respondents with negative implicit associations with air travel as they perceive air travel as significantly less safe than train travel in the context of the COVID-19 pandemic.

## 5.2 The role of implicit associations in travel mode preferences

As the first study to investigate implicit air travel associations regarding long-distance travel mode choices, our implicit measure of affect significantly correlates with continental air and train travel intentions but not intercontinental air travel intentions (see RQ2). The analysis of ten European destinations confirmed the critical role of implicit associations in travelers' mode preferences between the train and plane. Thus, the IAT results help better understand long-distance travel mode choices in choice settings with a viable climate-friendly alternative to the plane, such as the train. The insignificant results for intercontinental air travel could relate to the more difficult choice setting of intercontinental travel destinations with limited alternative transportation modes<sup>7</sup>. This contextual factor decisively determines the choices a traveler can make. Once a destination is selected, travelers do not necessarily have an alternative to flying. Although our results for intercontinental air travel intentions were not statistically significant, the share of intercontinental air travel plans for respondents with negative implicit associations with air travel ( $M = 9.9\%$  of overall future travel plans) is lower compared to those with positive ( $M = 12.4\%$ ) or little or no ( $M = 13.1\%$ ) implicit associations. These results could indicate that if social norms associated with flying continue to evolve (see Cousse et al., 2020; Gössling et al., 2020), these differences will likely become more pronounced in the future.

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<sup>7</sup> We would like to note, that there are viable options to travel by train from Europe to China Smith (2021a) or to travel by ferry from Europe to the US Smith (2021b). However, the time and cost implications of those options compare more unfavorably to air travel than on inner-European connections.

### **5.3 The role of implicit associations vs. environmental attitudes in travel mode preferences**

In contrast to the IAT results, the measure of environmental attitudes (Haws et al., 2014) was not significantly related to future travel mode intentions in any of the three regression models (see RQ3). Implicit associations were not only more clearly linked to continental air and train travel intentions. But they also predicted travel mode preferences between air and train travel for eight out of ten European destinations, while environmental attitudes predicted only six of them. These results corroborate the evidence from previous studies suggesting a gap between environmental attitudes and air travel behavior (Barr et al., 2010; Higham et al., 2016; Alcock et al., 2017). They also indicate that the attitude-behavior gap may partly persist as environmental attitudes do not capture the full range of a person's attitude towards air travel behavior. Considering the emotional dimension of travel mode choices (see Steg, 2005) and using implicit measures of inquiry as proposed by Passafaro (2020) have proven to be more insightful in ascertaining future continental travel intentions than measuring explicit environmental attitudes. This central finding of our study also adds to an increasing number of IAT studies highlighting the importance of implicit measures of inquiry in decision-making in general (Yang et al., 2012) and in the context of transportation research (Chen & Chancellor, 2019; Ledesma et al., 2019). The results thus emphasize the necessity of going beyond merely measuring environmental attitudes.

## **6 Conclusion**

### **6.1 Main Conclusions**

In this research, we investigated the role of emotions in travel mode preferences between plane and train for long-distance leisure travel. The presented results are relevant as they for the first time clearly lay bare the implicit associations with air travel and reveal their important role in travel mode decisions in the context of continental long-distance travel. The majority of individual respondents display strong and rather strong negative and positive implicit associations with air travel. We found respondents with negative implicit associations to be significantly more environmentally friendly than respondents with positive implicit associations with air travel. Those with positive associations found air travel relatively more exciting than train travel.

These results for sub-groups within our sample reflect the tension between social norms that postulate air travel as exciting and socially desirable and those that relate air travel to its environmental unfriendliness and evoke emotions of shame and guilt.

Investigating the relationship between implicit associations, travel intentions and mode preferences revealed that respondents with negative implicit air travel associations are more likely to travel by train and less likely by plane than respondents with positive implicit associations. The latter are significantly more likely to travel by plane and less likely by train for their continental trips. The regression confirmed the importance of implicit associations in travel mode intentions. Compared to implicit associations, which consider the emotional dimension of air travel, environmental attitudes (Haws et al., 2014) are not significantly related to future travel intentions.

## **6.2 Implications for industry and policy**

A central message for industry actors and policymakers in the field is that travel mode choices are strongly related to emotional factors. Thus, interventions directed at low-carbon behavior will need to go beyond public appeals or financial incentives and consider travelers' emotional attachments. To foster climate-related behavior change, we propose using the contextual factors that have been fostering the emotional attractiveness of air travel in the past as intervention points, namely advertisement strategies and social media activity. Thereby, it will be necessary to move away from advertisement and social media narratives that promote air travel. Doing so requires adequately targeting respondents with negative and positive implicit associations with air travel. Respondents with negative implicit air travel associations find train travel significantly more exciting than air travel, are more environmentally friendly, and perceive air travel as more environmentally unfriendly than respondents with positive implicit air travel associations. Thus, targeting travelers with emotional messages about the excitement of train travel and reminding them that air travel is one of the most carbon-intensive travel activities (Scott et al., 2010; Lenzen et al., 2018) is important. However, this may not be sufficient to address those with positive implicit associations with air travel for whom the excitement of the air travel experience is a central characteristic. Convincing those travelers to fly less may additionally require limiting the spread of positive emotions linked to the air travel experience. Specifically, policymakers and industry stakeholders should consider the following measures:

Air travel advertisements, which have been linked to the establishment of the social norm of flying (Cohen & Gössling, 2015), often rely on affective and catchy messages to promote air travel (see e.g., EasyJet, 2017). In this respect, policymakers could mandate the aviation industry to integrate a label into their advertisements communicating the CO<sub>2</sub> emissions caused by the air travel experience (for the effectiveness of eco-labeling in promoting sustainable behavior see, e.g., Heinzle and Wüstenhagen (2012)). Another option would be the introduction of a warning sign about how flying endangers the health of the planet, analogous to what has been done in the context of tobacco advertising. Helping consumers prioritize their flights (Gössling et al., 2019), particularly intercontinental ones, will also require radical changes in terms of destination management and which destinations marketers target with their advertisement strategies (Higham et al., 2019; Gössling & Higham, 2020). The disruption by the COVID-19 pandemic provides destination managers with the opportunity to find innovative solutions to emotionally appeal to local and regional tourism also in the long-run (see also Gössling, 2020; Gössling & Higham, 2020).

Apart from industry advertisement, social media has been a powerful accelerator of promoting the desire to travel in general (White, 2010; Gössling & Stavrinidi, 2016), destination choices (Scholl-Grissemann et al., 2020) and air travel specifically (Gössling, 2019; Oswald & Ernst, 2020). Thus, railway companies should continue using social media to encourage positive associations with train travel, slow travel and destinations that can be reached by train (see DeutscheBahn, 2019). Furthermore, influencers and celebrities, that importantly influence the status quo of the flying norm (Gössling, 2019), could be powerful in helping spread negative feelings about air travel at the societal level by promoting #flightshame on social media or by signing a pledge to be flight free.

### **6.3 Limitations and further research**

In the realm of travel and transportation mode choice literature, our study is one of the first to include implicit measures of inquiry, namely the IAT. Our findings provide evidence to suggest that further exploring the role of affect and measuring implicit associations may be insightful to better understand consumer travel mode decisions and may be conducive to promote low-carbon travel strategies. At the same time, our study encountered some limitations that open up opportunities for further research.

Firstly, the IAT results significantly correlated with continental air travel and train travel, however, not with intercontinental air travel intentions. Investigating this gap between implicit associations and intercontinental air travel intentions may require giving more attention to travelers' destination choices (Gössling & Higham, 2020). Specifically, future researchers could explore the relationship between travel mode choices and implicit associations with destinations that are reachable by continental air/train travel compared to intercontinental destinations which require air travel.

Secondly, the study sample is representative of the Swiss-German speaking population. However, frequent air travel and the high CO<sub>2</sub> emissions resulting from it are issues that need to be tackled on a global scale. Other studies may investigate implicit associations with air travel in countries with varying flying patterns of travelers but a GDP per capita that is comparable to the one of Switzerland and where social norms are also visibly changing, such as Germany (Gössling et al., 2020) or Sweden where the #Flygskam (#Flightshame) originated (Hook, 2019).

Finally, apart from confirming the importance of calls to give more attention to affect and emotions when it comes to travel mode choices (Souche-Le Corvec & Zhao, 2020), our regression models also highlight the central role of past behavioral patterns in travel mode choices. This confirms extant literature suggesting that habits, familiarity, and past behavior are key to daily travel mode choices (Lanzini & Khan, 2017), travel decisions more generally, including destination choices (Milman & Pizam, 1995; Kim et al., 2019; Tham et al., 2020) and long-distance mode choices between air and train travel (Bieger & Laesser, 2004; Dällenbach, 2020). These results highlight the importance of future research to consider employing experimental methods to study the effectiveness of specific behavioral interventions. In this respect, the COVID-19 pandemic is a particularly interesting real-life experiment (Cohen, 2020). It disrupted habitual travel behaviors, and people are becoming familiar with new ones. Future research could investigate whether the rediscovery of regional tourism during the COVID-19 pandemic has resulted in new positive associations with low-carbon travel modes or whether pent-up demand for new experiences will have led to more positive implicit associations with air travel.

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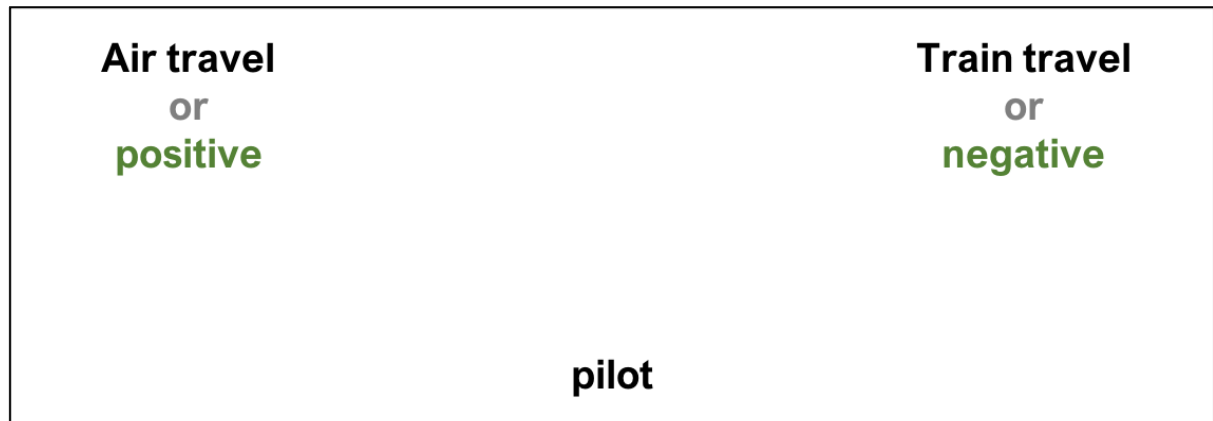
## 8 Appendix

### Appendix A Socio-demographic characteristics of the sample.

| Variables             |             | Sample (N=412) | Swiss Population <sup>a</sup> |
|-----------------------|-------------|----------------|-------------------------------|
| Gender                | Female      | 51%            | 50%                           |
|                       | Male        | 49%            | 50%                           |
| Age                   | 20-29       | 16%            | 16%                           |
|                       | 30-39       | 19%            | 19%                           |
|                       | 40-49       | 19%            | 19%                           |
|                       | 50-59       | 20%            | 20%                           |
|                       | 60-69       | 15%            | 15%                           |
|                       | 70-79       | 11%            | 11%                           |
| Political orientation | SVP         | 27%            | 26%                           |
|                       | SP          | 18%            | 17%                           |
|                       | FDP         | 15%            | 15%                           |
|                       | CVP         | 9%             | 11%                           |
|                       | BDP         | 4%             | 2%                            |
|                       | GLP         | 5%             | 8%                            |
|                       | Grüne       | 7%             | 13%                           |
|                       | Other / N/A | 16%            | 8%                            |

<sup>a</sup> Data of the Swiss population are based on Swiss Federal Statistical Office (FSO) (2019b) for age and gender and on Swiss Federal Statistical Office (FSO) (2019a) for political orientation.

**Appendix B** IAT: Compatible pair, Allocation of a stimuli representing a target category (air vs. train travel).



**Appendix C** IAT: Incompatible pair, Allocation of a stimuli representing an attribute (positive vs. negative).



**Appendix D** Mean, Standard deviation and Paired *t*-test, Explicit emotional associations (excitement vs. stress), Perceptions about travel safety in the COVID-19 pandemic

|                                                                 | Mean and standard deviation |      |              |      | Paired <i>t</i> -test       |
|-----------------------------------------------------------------|-----------------------------|------|--------------|------|-----------------------------|
|                                                                 | Air travel                  |      | Train travel |      |                             |
|                                                                 | M                           | SD   | M            | SD   |                             |
| <i>Explicit emotional associations (excitement vs. stress)</i>  |                             |      |              |      |                             |
| Positive implicit associations                                  | 4.91                        | 1.82 | 4.58         | 1.52 | $t(166) = 2.071, p= 0.040$  |
| Little or No impl. associations                                 | 4.91                        | 1.75 | 4.77         | 1.58 | $t(99) = 0.625, p= 0.533$   |
| Negative implicit associations                                  | 4.58                        | 1.73 | 5.03         | 1.55 | $t(116) = -2.770, p= 0.007$ |
| Overall sample (N=384)                                          | 4.81                        | 1.78 | 3.77         | 1.55 | $t(383) = 0.399, p= 0.690$  |
| <i>Perceptions about travel safety in the COVID-19 pandemic</i> |                             |      |              |      |                             |
| Positive implicit associations                                  | 3.88                        | 2.08 | 3.93         | 1.93 | $t(164) = -0.354, p= 0.724$ |
| Little or No impl. associations                                 | 4.32                        | 1.97 | 4.39         | 1.99 | $t(94) = -0.374, p= 0.709$  |
| Negative implicit associations                                  | 3.63                        | 2.02 | 4.39         | 1.95 | $t(122) = -4.535, p< 0.001$ |
| Overall sample (N=383)                                          | 3.91                        | 2.05 | 4.19         | 1.96 | $t(382) = -2.879, p= 0.004$ |

**Appendix E** Mean, Standard deviation and ANOVA, Environmental attitudes of participants, Perceptions about air travel's environmental friendliness.

|                                                                  | M    | SD   | ANOVA                                       |
|------------------------------------------------------------------|------|------|---------------------------------------------|
| <i>Environmental attitudes</i>                                   |      |      |                                             |
| Positive implicit associations                                   | 4.31 | 1.50 | $F_{(2, 409)} = 12.95, p < 0.001$           |
| Little or No implicit associations                               | 4.61 | 1.31 |                                             |
| Negative implicit associations                                   | 5.08 | 1.27 |                                             |
| Total sample (N=412)                                             | 4.63 | 1.35 |                                             |
| <i>Perceptions about air travel's environmental friendliness</i> |      |      |                                             |
| Positive implicit associations                                   | 2.50 | 1.50 | Welch's $F_{(2, 242.66)} = 5.52, p = 0.005$ |
| Little or No implicit associations                               | 2.50 | 1.51 |                                             |
| Negative implicit associations                                   | 2.03 | 1.25 |                                             |
| Total sample (N=412)                                             | 2.35 | 1.45 |                                             |

**Appendix F** Post hoc test results, Environmental attitudes of the participants, Perceptions about air travel's environmental friendliness.

| <b>Differences between respondents with positive, little or no and negative implicit associations with air travel.</b> |                        |           |                 |                     |                    |
|------------------------------------------------------------------------------------------------------------------------|------------------------|-----------|-----------------|---------------------|--------------------|
|                                                                                                                        | <b>Mean difference</b> | <b>SD</b> | <b><i>p</i></b> | <b>95% interval</b> | <b>Confidence</b>  |
|                                                                                                                        |                        |           |                 | <b>Lower Bound</b>  | <b>Upper Bound</b> |
| <b><i>Environmental attitudes (Bonferroni post hoc test results)</i></b>                                               |                        |           |                 |                     |                    |
| Positive – negative                                                                                                    | -0.77                  | 0.15      | 0.000           | -1.131              | -0.405             |
| Positive – little or no                                                                                                | -0.30                  | 0.16      | 0.200           | -0.691              | 0.092              |
| Negative – little or no                                                                                                | 0.47                   | 0.17      | 0.022           | 0.052               | 0.885              |
| <b><i>Perceptions about air travel's environmental friendliness (Games-Howell post hoc test results)</i></b>           |                        |           |                 |                     |                    |
| Positive – negative                                                                                                    | 0.47                   | 0.16      | 0.008           | 0.10                | 0.84               |
| Positive – little or no                                                                                                | 0.00                   | 0.19      | 1.000           | -0.44               | 0.45               |
| Negative – little or no                                                                                                | -0.47                  | 0.19      | 0.033           | -0.91               | -0.03              |

**Appendix G** Games-Howell post hoc test results, Intercontinental air travel intentions, Continental air travel intentions, Continental train travel intentions.

| Differences between respondents<br>with positive, little or no and<br>negative implicit associations<br>with air travel. | Mean<br>difference | SD    | <i>p</i> | 95%<br>interval | Confidence     |
|--------------------------------------------------------------------------------------------------------------------------|--------------------|-------|----------|-----------------|----------------|
|                                                                                                                          |                    |       |          | Lower<br>Bound  | Upper<br>Bound |
| <i>Intercontinental air travel intentions</i>                                                                            |                    |       |          |                 |                |
| Positive – negative                                                                                                      | 2.53               | 2.20  | 0.482    | -2.639          | 7.696          |
| Positive – little or no                                                                                                  | -0.74              | 2.41  | 0.950    | -6.420          | 4.947          |
| Negative – little or no                                                                                                  | -3.27              | 2.55  | 0.409    | -9.293          | 2.763          |
| <i>Continental air travel intentions</i>                                                                                 |                    |       |          |                 |                |
| Positive – negative                                                                                                      | 12.24              | 2.86  | 0.000    | 5.509           | 18.979         |
| Positive – little or no                                                                                                  | 7.35               | 3.09  | 0.048    | 0.055           | 14.647         |
| Negative – little or no                                                                                                  | -4.89              | 3.08  | 0.254    | -12.170         | 2.384          |
| <i>Continental train travel intentions</i>                                                                               |                    |       |          |                 |                |
| Positive – negative                                                                                                      | -10.043            | 2.672 | 0.001    | -16.350         | -3.736         |
| Positive – little or no                                                                                                  | -8.228             | 2.597 | 0.005    | -14.367         | 4.947          |
| Negative – little or no                                                                                                  | 1.816              | 3.201 | 0.838    | -5.736          | 9.367          |

**Appendix H** Multiple regression Model 1 with continental air travel intentions as the dependent variable.

| Variables                             | B       | S.E.  | Beta   | t      | Sig.  | 95% C.I. for B |         |
|---------------------------------------|---------|-------|--------|--------|-------|----------------|---------|
|                                       |         |       |        |        |       | Lower          | Upper   |
| Implicit associations with air travel |         |       |        |        |       |                |         |
| negative (vs. positive)               | -11.479 | 2.761 | -0.210 | -4.158 | 0.000 | -16.906        | -6.051  |
| little or no (vs. positive)           | -9.065  | 2.872 | -0.153 | -3.156 | 0.002 | -14.711        | -3.418  |
| Environmental attitudes               |         |       |        |        |       |                |         |
| env. friendly (vs. env. unfriendly)   | 4.024   | 2.755 | 0.074  | 1.460  | 0.145 | -1.393         | 9.440   |
| neutral (vs. env. unfriendly)         | 1.182   | 4.840 | 0.012  | 0.244  | 0.807 | -8.332         | 10.696  |
| Past continental air travel behavior  |         |       |        |        |       |                |         |
| infrequent (vs. frequent)             | -28.159 | 3.789 | -0.544 | -7.432 | 0.000 | -35.607        | -20.711 |
| moderate (vs. frequent)               | -14.347 | 3.701 | -0.280 | -3.876 | 0.000 | -21.623        | -7.071  |
| Pol. att. green (vs. other parties)   | -2.291  | 3.575 | -0.030 | -0.641 | 0.522 | -9.319         | 4.737   |
| Gender male (vs. female)              | -2.975  | 2.338 | -0.058 | -1.272 | 0.204 | -7.571         | 1.622   |
| Age                                   | -0.108  | 0.074 | -0.067 | -1.457 | 0.146 | -0.254         | 0.038   |
| Constant                              | 52.200  | 4.963 |        | 10.518 | 0.000 | 42.443         | 61.957  |

**Appendix I** Multiple regression Model 2 with intercontinental air travel intentions as the dependent variable.

| Variables                                        | B       | S.E.  | Beta   | t      | Sig.  | 95% C.I. for B |        |
|--------------------------------------------------|---------|-------|--------|--------|-------|----------------|--------|
|                                                  |         |       |        |        |       | Lower          | Upper  |
| <b>Implicit associations with air travel</b>     |         |       |        |        |       |                |        |
| negative (vs. positive)                          | -1.195  | 2.058 | -0.029 | -0.580 | 0.562 | -5.240         | 2.851  |
| little or no (vs. positive)                      | 0.893   | 2.154 | 0.020  | 0.414  | 0.679 | -3.342         | 5.127  |
| <b>Environmental attitudes</b>                   |         |       |        |        |       |                |        |
| env. friendly (vs. unfriendly)                   | -1.843  | 2.059 | -0.045 | -0.895 | 0.371 | -5.891         | 2.206  |
| neutral (vs. env. unfriendly)                    | 3.577   | 3.649 | 0.048  | 0.980  | 0.328 | -3.598         | 10.751 |
| <b>Past intercontinental air travel behavior</b> |         |       |        |        |       |                |        |
| infrequent (vs. frequent)                        | -16.409 | 3.952 | -0.400 | -4.152 | 0.000 | -24.179        | -8.639 |
| moderate (vs. frequent)                          | 1.533   | 4.168 | 0.036  | 0.368  | 0.713 | -6.661         | 9.726  |
| <b>Pol. att.</b> green (vs. other parties)       | 1.086   | 2.681 | 0.019  | 0.405  | 0.686 | -4.184         | 6.356  |
| <b>Gender</b> male (vs. female)                  | 2.912   | 1.758 | 0.076  | 1.656  | 0.098 | -0.544         | 6.367  |
| <b>Age</b>                                       | 0.016   | 0.055 | 0.013  | 0.286  | 0.775 | -0.093         | 0.125  |
| Constant                                         | 21.288  | 4.975 |        | 4.279  | 0.000 |                |        |

**Appendix J** Multiple regression Model 3 with continental train travel intentions as the dependent variable.

| Variables                             | B       | S.E.  | Beta   | t      | Sig.  | 95% C.I. for B |         |
|---------------------------------------|---------|-------|--------|--------|-------|----------------|---------|
|                                       |         |       |        |        |       | Lower          | Upper   |
| Implicit associations with air travel |         |       |        |        |       |                |         |
| negative (vs. positive)               | 5.969   | 2.413 | 0.124  | 2.474  | 0.014 | 1.225          | 10.714  |
| little or no (vs. positive)           | 4.485   | 2.549 | 0.086  | 1.760  | 0.079 | -0.526         | 9.495   |
| Environmental attitudes               |         |       |        |        |       |                |         |
| env. friendly (vs. unfriendly)        | 1.051   | 2.413 | 0.022  | 0.435  | 0.664 | -3.693         | 5.795   |
| neutral (vs. env. unfriendly)         | -6.919  | 4.238 | -0.079 | -1.633 | 0.103 | -15.250        | 1.412   |
| Past train travel behavior            |         |       |        |        |       |                |         |
| infrequent (vs. frequent)             | -17.028 | 2.426 | -0.375 | -7.018 | 0.000 | -21.798        | -12.259 |
| moderate (vs. frequent)               | -7.328  | 2.662 | -0.146 | -2.752 | 0.006 | -12.562        | -2.094  |
| Pol. att. green (vs. other parties)   | 15.058  | 3.127 | 0.221  | 4.815  | 0.000 | 8.910          | 21.206  |
| Gender male (vs. female)              | 0.659   | 2.052 | 0.015  | 0.321  | 0.748 | -3.374         | 4.692   |
| Age                                   | 0.091   | 0.064 | 0.064  | 1.420  | 0.156 | -0.035         | 0.216   |
| Constant                              | 17.636  | 4.098 |        | 4.304  | 0.000 | 9.580          | 25.692  |

# Curriculum Vitae



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## Education

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|                   |                                                                                                                                                                                                                                                                     |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 09/2017 – today   | <b>University of St. Gallen (HSG), Switzerland</b><br>Ph.D. Candidate at the Institute for Economy and the Environment in the field of social acceptance of renewable energies and mobility behavior (Ph.D. Program in International Affairs and Political Economy) |
| 09/2013 – 12/2016 | <b>University of St. Gallen (HSG), Switzerland</b><br>Master of Arts in International Affairs and Governance (M.A. HSG)                                                                                                                                             |
| 09/2009 – 06/2013 | <b>University of St. Gallen (HSG), Switzerland</b><br>Bachelor of Arts in International Affairs and Governance (B.A. HSG)                                                                                                                                           |
| 08/2002 – 07/2008 | <b>Kantonsschule Limmattal, Switzerland</b><br>Swiss Matura                                                                                                                                                                                                         |

## Professional experience

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|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 05/2017 – today   | <b>University of St. Gallen (HSG), Switzerland</b><br>Research Associate and Programme Manager of the CEMS Model UNFCCC at the Chair for Management of Renewable Energies |
| 01/2009 – 04/2017 | <b>S-Access, Switzerland</b><br>Assistant to the CEO                                                                                                                      |
| 10/2008 – 12/2008 | <b>SK Stones &amp; Buzzintown, India</b><br>Marketing internships in b2b industry and digital commerce                                                                    |