



## COVID-19 – A window of opportunity for the transition toward sustainable mobility?



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### ABSTRACT

The mobility sector was one of the sectors most affected by COVID-19 and its political restrictions, with, inter alia a huge drop in mobility behavior due to travel bans, lockdowns, and a reduced need to be mobile. The present study examined the potential of COVID-19 restrictions aiming at containing the spread of the virus to be a window of opportunity for the transition toward sustainable mobility by breaking up strongly habitualized daily and travel mobility behaviors through changes of behavioral contexts. We conducted an online survey in a sample representative for the German population ( $N = 3092$ ) to study the consequences of the COVID-19 restrictions on Germans' daily and travel mode choices and on their wishes for future mobility. Furthermore, we examined the moderating effects of Germans' personal norms to protect the climate on changes in their mobility behavior toward sustainable mobility, both within and beyond the corona pandemic. In line with previous research, the present study shows an overall reduction of mobility across almost all modes of transport for daily and travel mobility during time periods of COVID-19 restrictions compared to pre-COVID-19-times, with different transport modes being affected differently. Our findings additionally point out the relevance of personal norms to protect the climate for the transition toward sustainable mobility behavior. Altogether, the present study provides first empirical evidence for the corona pandemic to represent a window of opportunity for the transition toward sustainable mobility. Furthermore, the study also points out relevant directions for further research.

### Introduction

#### *Changes in daily, work, and travel mobility during the corona pandemic*

The corona pandemic confronts the international community with unprecedented challenges and threats. Since the beginning of 2020, governments around the globe started to take unparalleled measures (i.e., COVID-19 restrictions) to limit the spread of the virus. The associated regulations have concurrently extensive consequences for people's daily lives. Social life has come to a halt, especially in countries that have enforced national (complete) lockdowns, such as Spain and Germany. One sector hugely affected by the consequences of the pandemic and its associated measures is the mobility sector (Muhammad et al., 2020). National lockdowns, the closure of borders, the cancellation of events, the shift of work towards home office, etc., have major implications for people's daily, work, as well as travel mobility. Studies analyzing daily mobility patterns via phone data show a general reduction in global

mobility compared to pre-COVID-19-times (e.g., Dahlberg et al., 2020; Kramer & Kramer, 2020; Muhammad et al., 2020; Warren & Skillman, 2020). In Germany, the average daily distance covered per person decreased by almost 50% in response to the first lockdown, which took place mid-March to the beginning of June 2020 (Allgemeiner Deutscher Fahrrad-Club, 2020). In Sweden (Heiler et al., 2020) and Austria (Dahlberg et al., 2020), people resided in significantly smaller radiuses since the beginning of the national lockdowns (a decrease of approx. 60%). The number of short distances travelled increased, while the number of long distances travelled decreased. Furthermore, people spent less time in industrial and commercial areas as well as city centers, and commuting routes were frequented less in response to the lockdowns (Dahlberg et al., 2020). Instead, people spent more time in residential areas and left these less frequently. In response to COVID-19 restrictions, mobility for the purpose of errands in Germany decreased from February to April 2020 by 13%, even more so did trips to retail and for leisure purposes (–58%; Muhammad et al., 2020).

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Another reason for the overall reduced mobility lies in changes in the working world that came with the pandemic. The increased amount of people working from home, alongside short time work, and home schooling, resulted in a decrease in commutation to work in Germany of 23% by late March 2020 compared to pre-COVID-19-times, and a decrease in work-related travel of 19%. The percentage of people that commuted to work or training place every day decreased from 66% to 32% (Allgemeiner Deutscher Automobil-Club, 2020). Two-thirds of Germans reported an omission of journeys due to home office, almost half reported an omission of journeys due to video and phone conferences (Anke et al., 2020).

The public transport sector reported one of the largest decreases in usage since the beginning of the pandemic. This was, alongside the general decreased need to be mobile, largely due to a higher perceived risk of infection. Heiler et al. (2020), e.g., showed a reduction in metro-usage in Vienna, Austria, of four-fifth compared to before the crisis. According to the Allgemeiner Deutscher Fahrrad-Club (2020), the German public transport sector has lost up to 95% of its customers during the first national lockdown. Krämer (2020) found that, while the respondents intended to use cars 8% more after the termination of the COVID-19 restrictions in Germany, they reported a 12% lower intention to use trains. Accordingly, cars were rated much more attractive than trains (since it guarantees safe mobility in one's comfort zone; Krämer, 2020).

#### *Changes toward sustainable mobility in response to COVID-19 restrictions*

Alongside the reduced usage of public transport due to COVID-19 and a relatively increased usage of cars, other COVID-19 induced mobility tendencies lean more toward sustainability. Across the world, a relative increase in bike usage and in the coverage of distances by foot was registered. According to the Allgemeiner Deutscher Fahrrad-Club (2020), bike usage in Germany decreased less than the usage of other transport modes, and its usage increased relatively. As it was/ is the case for cars, people in Finland and Sweden reported to feel safer when using the bike or walking, due to a smaller fear of infection (Kanda & Kivimaa, 2020). Compared to pre-COVID-19-times, people, e.g. in the US, covered smaller distances per day (e.g., Warren & Skillman, 2020), allowing them to take alternative modes of transportation, i.e. the bike. In Cologne, traffic measure systems measured an average increase of 5% of bike rides in the city since the introduction of the COVID-19 restrictions compared to previous years (Köln, 2020).

The reduction in travel mobility, especially in aviation, was by far the most drastic change in the transportation sector. The average global commercial aviation activity mid-April 2020 was 75% lower than the annual average from 2019 (Abu-Rayash & Dincer, 2020). In addition, 24% of the Germans reported lower intentions to fly – even for post-COVID-19-times. The most relevant reasons mentioned for these decreased intentions to fly were the contact in the plane/ fear of infection, a reduced need, and the negative environmental impact of flying.

As shown above, the corona pandemic and its associated restrictions reshaped the mobility sector drastically. This had immediate consequences for sustainability, the most obvious being a decrease in global greenhouse gas emissions. According to Le Quéré et al. (2020), the mobility reductions in the first two months of the pandemic led to a decrease in global CO<sub>2</sub>-emissions by 17%. Emissions caused by aviation decreased by 60%, which contributed to the global emission reduction by 10%. Apart from these direct impacts, the changes in the mobility sector also have indirect consequences for the transformation toward sustainability. The pandemic and its restrictions affected people's daily transport mode choices through changing external factors of their mobility behavior. These changes can result in a breaking-up of peoples' generally very stable mobility habits (see, e.g., Krämer, 2020). Habits in daily transport mode choice can be conceptualized as scripts or automatized decision making that lead to

unreflected decisions (see, e.g., Klöckner & Matthies, 2012). The strong habitualization of a behavior therefore suppresses a reflected behavioral decision process. That is why behavioral effects of normative predictors like strong internalized moral obligations (i.e., *personal norms*, see e.g., Harland et al., 1999) to protect the climate (e.g., by using the bike instead of the car for daily mobility) are eliminated under conditions of strong habitualization (Hunecke et al., 2001; Klöckner & Matthies, 2004). Several studies have shown that these habitualizations can be overcome or "broken up" by major temporal changes of the situation in which individuals make (transport mode) choices. This can lead to more reflected behavioral decisions, which in turn can again be affected by normative predictors such as personal norms to protect the climate (e.g., Matthies et al., 2006). The corona pandemic and its restrictions can be seen as such a major change of situation. The corona pandemic can therefore serve as a *window of opportunity* (see, e.g., Verplanken & Roy, 2016) for a long-lasting, positive transformation toward sustainability, e.g., in the mobility sector.

#### *The corona pandemic as a window of opportunity for the transition toward sustainable mobility*

By changing their ways of consumption or lifestyle, people can actively participate in the great transformation toward sustainability (e.g., Nielsen et al., 2020; Stern, 2000). Since mobility behavior accounts for approx. 18.8% of the per capita CO<sub>2</sub>-emissions in Germany, it is of special relevance for the great transformation (Umweltbundesamt, 2020). Since the 1990 s, the level of passenger transportation in Germany increased constantly (e.g., from 875 billion passenger km in 1991 to 1 169 billion passenger km in 2019; i.e., an increase by 34%). Levels of motorized private transport (i.e., cars and motorcycles) increased substantially (by 28.5%), accounting for 73.4% of all passenger km in 2019. Furthermore, the highest increase-rate in German passenger transportation was found for aviation: From 1991 to 2019, aviation performance increased by 218%.

The passenger volume in public transport increased by 30% from 1991 to 2019, accounting for 15.3% of all distances covered in 2019. Combined with the distances traveled by non-motorized individual modes of transport (i.e., walking and cycling), these more sustainable modes of transport accounted for 20.5% of all passenger km in Germany in 2019 (Bundesministerium für Verkehr und digitale Infrastruktur, 2020; Umweltbundesamt, 2021) – while motorized individual transport modes accounted for 74%.

With regards to the promotion of sustainable mobility, studies show that long-term changes in daily and travel transport mode choices are difficult to achieve, even for people with strong personal norms to protect the climate (e.g., Chng et al., 2018). Especially daily mobility behavior is a greatly habitualized behavior, and habits are not easy to be broken up and changed (see, e.g., Chng et al., 2018; Klöckner & Matthies, 2004). Alongside, the experience of involuntary constraints (such as COVID-19 restrictions) can result in compensating behavior, given that limited goods often become more attractive (Cannon et al., 2019).

While previous studies on this subject expect COVID-19 restrictions to promote unsustainable mobility behavior in post-COVID-19-times (e.g., anticipating an increased use of cars and a decreased use of public transport; see e.g., de Haas et al., 2020), we believe that the corona pandemic could also represent an opportunity for the transition toward sustainable mobility and thus a window of opportunity for sustainability. As described above, COVID-19 restrictions represent extensive changes in peoples' behavioral contexts and the external factors affecting their mobility behavior. This could result in a breaking up of mobility habits, thus leading people to reconsider these habits. In environmental psychology, there is considerable evidence on the impact these temporal changes can have on changing habits and therefore initiate long-term behavior changes toward sustainability. This is especially the case, if the individual was already motivated to change

beforehand, and if the temporal changes were accompanied by positive experiences (e.g., Fujii et al., 2001; Lattarulo et al., 2019). It is therefore crucial to study how COVID-19 related imposed (e.g., lockdowns) and deliberate (e.g., home office-possibilities) restrictions affect peoples' mobility behavior.

### Research objectives and research hypotheses

The overall aim of the present study was to provide initial empirical evidence on the potential COVID-19 has to serve as a window of opportunity for the transition toward sustainable mobility in Germany. We assessed pro- and retrospective self-reported (intended) mobility behavior. Additionally, we studied potential changes in mobility behavior by taking into consideration existing data sets to avoid self-report biases. Our first research question was the following:

*Research Question RQ1a:* Did daily and travel mobility in Germany decrease during periods COVID-19 restrictions (April – June 2020) compared to pre-COVID-19-times?

Following research hypotheses were tested:

*Research hypothesis H1a:* The frequency of daily mobility behavior (i.e., the use of bikes, cars, public transport, walking, etc.) decreased during periods of COVID-19 restrictions (April – June 2020) compared to pre-COVID-19-times.

*Research hypothesis H1b:* During periods of COVID-19 restrictions (April – June 2020), the use of public transport decreased most compared to other modes of daily transport (bike, car).<sup>1</sup>

*Research hypothesis H1c:* The use of planes (travel mobility) decreased during periods of COVID-19 restrictions (April – June 2020) compared to pre-COVID-19-times.

In addition to investigating effects of COVID-19 restrictions on Germans' daily and travel mobility behavior, we studied effects on mobility-related cognitions, i.e., wishes for future mobility. To ensure validity and comparability, we compared wishes for future mobility reported during periods of COVID-19 restrictions (April – June 2020) to wishes assessed in 2019 in a comparable sample of Germans (see Section "Wishes for future mobility" for details):

*Research Question RQ1b:* Did wishes for future mobility change during periods of COVID-19 restrictions (i.e., April – June 2020) compared to pre-COVID-19-times?

The COVID-19 restrictions resulted in extensive changes in external factors (behavioral contexts) affecting mobility behavior. We therefore examined the implications of these changes on sustainable mobility behaviors:

*Research question RQ2:* Did COVID-19 related changes in external factors affect the behavioral transition toward sustainable mobility (i.e., (1) increased bike use during periods of COVID-19 related restrictions (April – June 2020) compared to the same period in 2019, (2) decreased intentions to fly in 2020 compared to 2019)?

Based on studies showing that habits can be broken up by great temporary changes, and assuming that personal norms to protect the climate become more relevant under the conditions of a temporarily

<sup>1</sup> We focused on bike, car and public transport, since these are the modes of daily transport used the most by Germans in pre-COVID-19-times (as shown by previous research, see e. g., Kunst, 2017; as well as shown by our own data with regards to the self-reported frequencies of use in pre-COVID-19-times, see Section "Frequencies of use of different modes of transport for daily and travel mobility" for details). Thus, for these modes of daily transports, highest changing levels seemed expectable.

changed situation (see Section "The corona pandemic as a window of opportunity for the transition toward sustainable mobility" for details), we assume the influence of external factors on behavioral transitions toward sustainable mobility to be moderated by personal norms to protect the climate. The following research hypothesis was tested:

*Research hypothesis H2:* The influence of COVID-19 related changes in external factors for mobility behavior is moderated by people's personal norms to protect the climate.

To provide further empirical evidence on potential moderating effects of personal norms to protect the climate on the behavioral transition toward sustainable mobility, we examined the intended use of daily transport modes (i.e., bikes, cars, public transport) and of transport modes for travel purposes (i.e., plane) for the next 12 months compared to pre-COVID-19-times:

*Research question RQ3:* Are the changes in the intended use of transport modes for daily and travel mobility for the next 12 months compared to pre-COVID-19-times moderated by people's personal norms to protect the climate?

We tested the following research hypotheses:

*Research hypothesis H3a:* Participants characterized by lower personal norms to protect the climate have higher intentions to use the car as well as to fly for the next 12 months compared to the past 12 months, while lower intentions are reported for frequencies of use for bike and public transport.

*Research hypothesis H3b:* Participants characterized by higher personal norms to protect the climate have lower or at least comparable intentions to use the car as well as to fly for the next 12 months compared to the past 12 months, while higher intentions are reported for frequencies of use for bike and public transport.

## Materials and methods

### Data collection and studied sample

Data for the present study was collected Germany-wide from June 29th to July 6th 2020 via online survey. Participant acquisition and data collection was carried out by an online access panel.

3357 people completed the survey. Out of those, the online access panel provider excluded 156 participants based on answering time and answers to open format questions. We additionally excluded 109 participants based on stricter criteria for answering time (exclusion of participants that finished the survey in less than 10 min), missing values and open format answers.  $N = 3092$  participants formed the final sample.

This final sample was representative for the German population with regards to age and gender (Statistisches Bundesamt, 2020a, 2020b, 2020c). Participants' age ranged from 18 to 69 years ( $M = 44.86$ ,  $SD = 14.39$ ). 50.5% of the participants were female. The sample was nearly representative for the German population regarding the highest education level (see Table 1 for details).

### Procedure and measures

Data was collected via online survey. First, participants' sociodemographic features were assessed to ensure representativity. Participants then provided information about their daily and travel mobility behavior in different time frames (i.e., during periods of COVID-19 restrictions in Germany, in pre- and post-COVID-19-times) and wishes for future mobility. Afterwards, we assessed the relevance of COVID-19 related external factors for participants' behavioral transition toward sustainable mobility as well as their personal norms to protect the climate. In the end, participants were thanked for their participation and

**Table 1**

Sociodemographic features of the final sample ( $N = 3092$ ), compared to the German population (Kunst, 2020; Statistisches Bundesamt, 2020a, 2020b, 2020c, 2021).

		Sample	German population
Age		$M = 44.86$ ( $SD = 14.39$ )	$M = 44.40$
Gender	Female	50.5%	50.6%
	Male	49.2%	49.4%
Highest education level	School was not finished	0.4%	4.0%
	School was finished	31.5%	29.6%
	Secondary education	30.8%	23.3%
	Higher education	37.2%	32.5%
Income	< €900	7.2%	$M =$
	€900 - €1300	8.0%	€3580
	€1301 - €1500	5.4%	
	€1501 - €2000	9.4%	
	€2001 - €2600	14.4%	
	€2601 - €4000	27.7%	
Number of inhabitants per place of residence	> €4000	28%	
	< 5000	17.5%	–
	5000–15000	16.1	–
	15000–50000	21.2	–
	50000–100000	10.9%	–
Car availability	100,000 and more	34.3	–
		–	81%*

given the opportunity to give feedback and communicate any remaining questions.

#### Daily and travel mobility during periods of COVID-19 restrictions and in pre-COVID-19-times

To measure participants' daily mobility behavior, we assessed the frequency of use of different transport modes (i.e., bike, car, public transport; see Table A.1 in Appendix for an overview). A five-point frequency scale (1 = "never/ nearly never" to 5 = "daily use/ nearly daily use") was used, introduced by the following sentence: "Please think about the last three months [the last 12 months]. Indicate how frequently you used the following means of transport."

Participants' travel mobility behavior was measured in a similar way. We used one item introduced by "Please think about the last three months [the last 12 months]. State how frequently you took a plane". The answer format was a five-point frequency scale (1 = "never" to 5 = "at least once a month").

#### Wishes for future mobility

Items to assess participants' wishes for future mobility were adopted from a national survey conducted by Acatech (2019) in February/ March 2019 (representative sample of Germans;  $N = 1\,301$ ). That way, wishes for future mobility could be compared between pre-COVID-19-times and during periods of COVID-19 restrictions (April – June 2020) without relying on retrospective measures.

In line with Acatech's survey (2019), our participants were asked the following question: "What would you like to change about your mobility?" Participants could choose any amount of the twelve given alternatives (e.g., "I would like to be more flexible when I drive or go somewhere."; "I would like to be less on the move." etc., see Table A.2 in Appendix for an overview). Multiple selections were possible.

#### The relevance of COVID-19 related changes in external factors for the transition toward sustainable mobility

We measured the effects of COVID-19 related changes in external factors on the transition toward sustainable mobility with regard to two types of sustainability-relevant mobility behaviors: (1) increased frequencies of bike use during periods of COVID-19 restrictions (April

– June 2020) compared to the same period in 2019 and (2) decreased intentions to fly in 2020 compared to 2019.

To assess whether participants used the bike more frequently during periods of COVID-19 restrictions (April – June 2020) compared to the same period in 2019, they expressed their agreement with the following statement: "To what extent do you agree with the following statements? During the last three months I have ridden the bike more than in the same period last year." on a seven-point Likert scale (1 = "do not agree at all" to 7 = "completely agree"). They were then presented with eight external factors (e.g., "I felt safer on the streets."; see Table A.3.1 in Appendix for an overview) and asked about whether these factors were potential reasons to ride the bike more frequently during the last three months on a seven-point Likert scale (1 = "do not agree at all" to 7 = "completely agree"). The factors originated in previous (psychological) research on external factors positively affecting bike usage, like short distance to the destination, time issues, perceived safety while riding the bike (e.g., Fahrrad-Monitor Deutschland, 2019), and the perception of others riding a bike (e.g., Bamberg, 2012). Furthermore, we asked participants about as how easy they perceived to use the bike instead of the car by assessing their agreement with three items (e.g., "It is easy for me to use the bike instead of the car."), answered on a seven-point Likert scale (see Table A.3.1 in Appendix for details). These items were integrated into the survey in order to capture a proxy of participants' different behavioral contexts determining bike use (e.g., higher frequencies of bike use are more probable for participants living in a more bike-friendly infrastructure than for participants living in a less bike-friendly infrastructure). We thus integrated this scale measuring the perceived ease-of-bike use in order to control for potential differences in participants' starting points. With  $\alpha = 0.90$ , this scale showed a very good internal reliability (e.g., Gliem & Gliem, 2003).

We assessed whether participants intended to fly less in 2020 compared to 2019 as an additional type of behavioral transition toward sustainable mobility. Participants indicated their agreement with the following statement: "To what extent do you agree with the following statements? In comparison to 2019 I intend to fly less this year." on a seven-point Likert scale (1 = "do not agree at all" to 7 = "completely agree"). Participants were presented with nine external factors and asked to what extent these represented relevant reasons to refrain from intending to take a plane: "Here you see a list of potential reasons for flying less. Please indicate to what extent these reasons are relevant for you.". The external factors were also chosen based on previous (psychological) research on relevant external factors for travel behavior, e.g., financial and planning uncertainty (Shamshiripour et al., 2020) or risk perception (Neuburger and Egger, 2020). We asked participants to indicate their agreement with nine external factors (e.g., "I am afraid of being stranded in a foreign country with no guarantee to get back to Germany"; see Table A.3.2 in Appendix for an overview) on a seven-point Likert scale (1 = "do not agree at all" to 7 = "completely agree"). We measured participants' perceived ease to avoid flying by assessing their agreement with three items (e.g., "It is easy for me to imagine avoiding flying."), answered on a seven-point Likert scale (see Table A.3.2 in Appendix for details). Those items were integrated into the survey in order to assess a proxy representing differences in participants' behavioral contexts generally determining flight avoidance (e.g., avoiding flights can be more difficult for participants, who usually have to undertake long-distance journeys for work than for participants, who do not have to undertake such work-related journeys). We thus integrated this scale measuring the perceived ease-of-flight avoidance in order to control for potential differences in participants' starting points. With  $\alpha = 0.91$ , this scale also showed a very good reliability (e.g., Gliem & Gliem, 2003).

#### Personal norms to protect the climate

Three items were used to measure participants' personal norm to protect the climate (e.g., "Based on my personal values, I feel obligated

to engage politically to protect the climate.”; see Table A.4 in Appendix for an overview), which were introduced by *To what extent do you agree with the following statements?*. These items were answered on a seven-point Likert scale (1 = “do not agree at all” to 7 = “completely agree”). With  $\alpha = 0.92$ , this scale showed a very good reliability (e.g., Gliem & Gliem, 2003).

#### *Intended use of transport modes for daily and travel mobility for the next 12 months*

Items to measure participants’ intended frequency of use of transport modes for daily and travel mobility were formulated in parallel to the measures assessing daily and travel mobility during periods of COVID-19 restrictions in Germany and in pre-COVID-19-times (see Section “Daily and travel mobility during periods of COVID-19 restrictions and in pre-COVID-19-times” for details). Intended daily mobility frequency was measured for the use of bikes, cars and public transport (see Table A.1 in Appendix for an overview). The item was introduced with “Please think about the next 12 months. State how frequently you will use the following means of transport.” And were answered on a five-point frequency scale (e. g., 1 = “never/ nearly never” to 5 = “daily use/ nearly daily use”).

In the context of travel mobility, we measured participants intention to fly with one item “Please think about the next 12 months. State how often you intend air travel.” This item was answered on a five-point frequency scale (e. g., 1 = “never” to 5 = “at least once a month”).

#### *Statistical analyses*

Statistical analyses were conducted using *Statistical Package for Social Science* (SPSS; version 26). To examine RQ1a and research hypotheses H1a, H1b and H1c, we compared the reported frequencies of use of the different modes of transport during periods of COVID-19 restrictions (April – June 2020) and pre-COVID-19-times by conducting *Wilcoxon tests* for each mode of transport (see Section “Frequencies of use of different modes of transport for daily and travel mobility” for the results of this data analyses). We examined RQ1b by comparing descriptive statistics referring to participants’ wishes for future mobility in the present study with data collected by Acatech in 2019 (see Section “Wishes for future mobility” for the results).

We then examined the effects of COVID-19 related changes in external factors on the transition toward sustainable mobility behavior (RQ2), and the moderating role of personal norms to protect the climate (research hypothesis H2). To that end, we conducted multiple regression analyses to examine effects of the external factors on (1) increased frequencies of bike use during periods of COVID-19 restrictions (April – June 2020) compared to the same time period in 2019, and (2) on participants’ intentions to fly less in 2020 compared to 2019. We entered participants’ age, gender, education as well as their perceived ease-of-bike use (or perceived ease-of-flight avoidance) in a first step in order to control for these variables. In the second step, we entered the agreement to the eight/ nine external factors as potential reasons for a (1) more frequent bike usage, and (2) intentions to fly less. In order to examine potential moderating effects of participants’ personal norms to protect the climate on the effects of external factors on the transition toward sustainable mobility behavior, we assigned our participants to two groups (high personal norms vs. low personal norms to protect the climate) based on a median split of this variable (see Section “Effects of COVID-19 related changes in external factors on the transition toward sustainable mobility behavior” for the results).

We examined RQ3 and research hypotheses H3a and H3b by comparing participants’ intended use of transport modes for daily and travel mobility for the next 12 months compared to pre-COVID-19-times via *Mann-Whitney U tests*. Again, we conducted these analyses separately for participants with different levels of personal norms to

protect the climate (high vs. low) to examine the potential moderating effect of participants’ personal norms (see Section “Intended daily and travel mobility for the next 12 months depending on personal norms” for the results).

## **Results**

### *Direct effects of COVID-19 restrictions on daily and travel mobility*

#### *Frequencies of use of different modes of transport for daily and travel mobility*

As can be seen in Table 2, nearly all modes of transport for daily mobility were used significantly less frequently during times of the COVID-19 restrictions compared to pre-COVID-19-times. Only the frequency of walking showed significant higher levels in periods of COVID-19 restrictions compared to pre-COVID-19-times. Thus, H1a was partially supported by our data.

With regard to the different effects of the restrictions on different modes of transport for daily mobility, results show that the most significant decrease in frequency of use was observed for public transport. H1b was therefore supported by our data. Since participants reported significantly lower frequencies of flying during periods of COVID-19 restrictions (April – June 2020) compared to pre-COVID-19-times, H1c was also supported by the data.

#### *Wishes for future mobility*

When comparing participants’ wishes for future mobility from the present study (in June/ July 2020) with wishes captured in a comparable sample of Germans in 2019, data analysis shows a mostly similar answer pattern. Highest selection rates were found for the wishes “spend less money” (with 37.5% in the present study and 40.0% in the study conducted by Acatech, 2019) and “bike or walk more” (with 44.3% in the present study and 34.0% in the study conducted by Acatech, 2019). In contrast, lowest rates were found for “fly less” (with 7.5% in the present study and 2.0% in the study conducted by Acatech, 2019; see Fig. 1 for details).

However, data also reveals several deviations between wishes for future mobility captured in the present study and those captured by Acatech (2019). The wish to “get around more environmentally friendly” was selected more frequently in the present study (39.5%) than in the study from Acatech (2019; 28.0%). Consistent with this result, and as already mentioned above, participants in the present study selected the wish to “bike or walk more” more frequently (with 44.3% in the present study and 34.0% in the study from Acatech (2019)). Furthermore, participants in the present study selected the wish their mobility to be “more relaxed” more frequently (with 37.9% in the present study and 25.0% in the study from Acatech, 2019).

#### *Effects of COVID-19 related changes in external factors on the transition toward sustainable mobility behavior*

When examining effects of COVID-19 related changes in external factors on higher frequencies of bike use during periods of COVID-19 restrictions (April – June 2020) compared to the same period in 2019, as well as on a decreased intentions to fly in 2020 compared to 2019, we divided our sample into two subgroups depending on participants’ personal norm to protect the climate. Based on the median of this variable ( $Md = 4.33$ ), we divided our sample into one group characterized by lower personal norms ( $N = 1437$ ) and one group characterized by higher personal norm ( $N = 1593$ ).

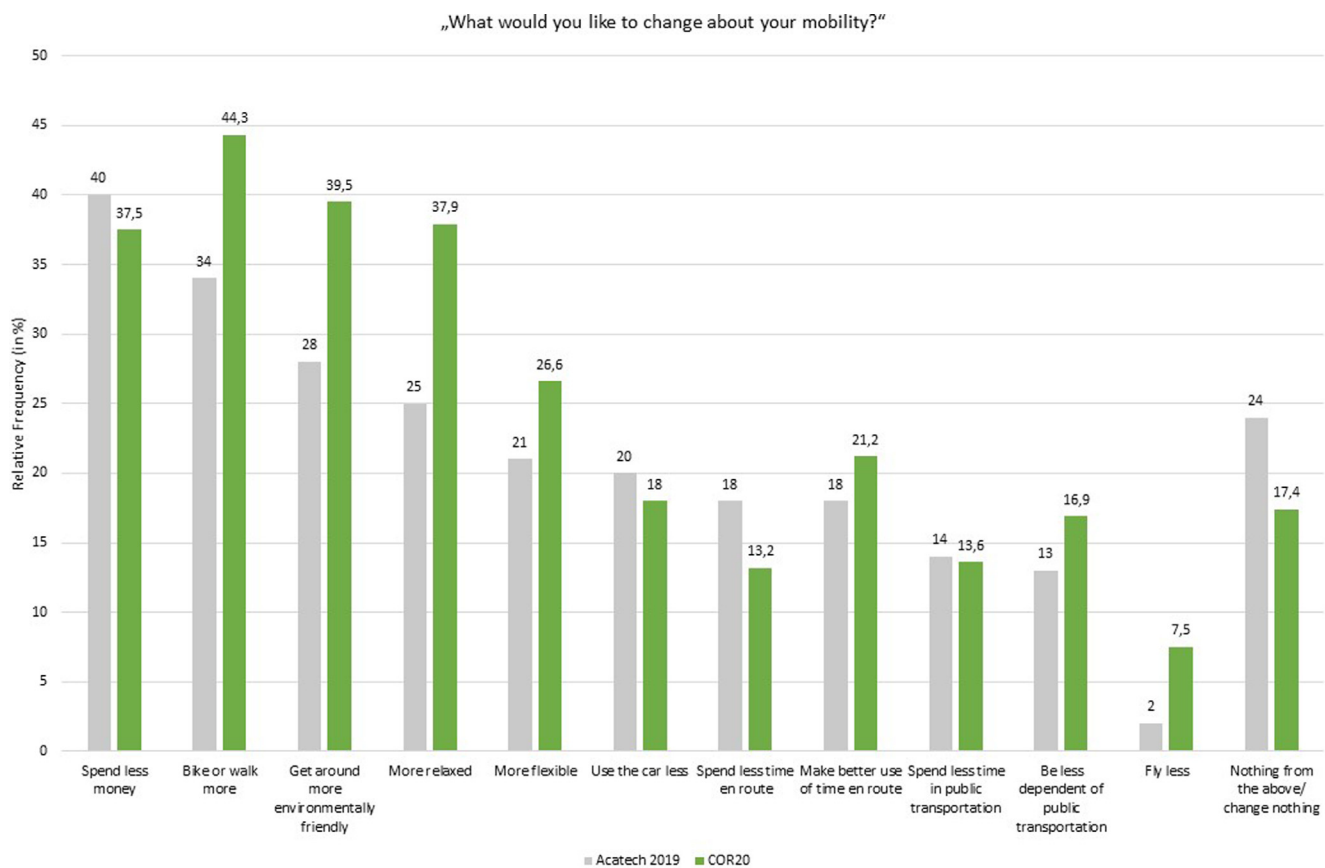
#### *Moderating effects of personal norms referring to higher frequencies of bike use*

In the low personal norm group, the examined external factors explained 29.8% of the variance in participants’ higher frequencies

**Table 2**

Comparisons of frequency of use of different transport modes for daily and travel mobility during periods of COVID-19 restrictions (April – June 2020) and pre-COVID-19-times.

Mode of Transport	Difference between the frequency of use during the past 12 months and the frequency of use during periods of political COVID-19 restrictions (April – June 2020)		Z	p
	Amount of positive differences	Amount of negative differences		
Bike	349	250	3.791	<0.001***
Car	364	136	9.401	<0.001***
Public transportation	611	297	11.082	<0.001***
By foot	275	366	-4.819	<0.001***
Long-distance train	376	189	7.940	<0.001***
Remote bus	166	61	6.981	<0.001***
Carsharing	95	50	4.018	<0.001***
Plane	119	0	9.637	<0.001***



**Fig. 1.** Wishes for future mobility in 2019 and in 2020 by comparison.

of bike use during periods of COVID-19 restrictions (April – June 2020) compared to the same period in 2019. After the significant influences of sociodemographic features and perceived ease-of-bike use were controlled for, the strongest effect was found for “destinations in close proximity” ( $\beta = 0.33, p < .001$ ). Furthermore, “perception of others riding bike” ( $\beta = 0.11, p < .01$ ) and “more time” ( $\beta = 0.07, p < .05$ ) significantly predicted higher frequencies of bike use during periods of COVID-19 restrictions (see again Table 3 for an overview).

In the high personal norm group, the examined external factors explained 33.0% of the variance in participants’ higher frequencies of bike use during periods of COVID-19 restrictions (April – June 2020) compared to the same period in 2019. No significant effects were found for sociodemographic features. After the significant effect of ease-of-bike use was controlled for, the strongest effect was found

for “destinations in close proximity“ ( $\beta = 0.28, p < .001$ ). Additionally, the external factors “more time” ( $\beta = 0.14, p < .01$ ) and perceived safety in traffic“ ( $\beta = 0.07, p < .05$ ) turned out as significant predictors (see again Table 3 for an overview).

Taken together, both the effect size patterns as well as the number of significant predictors depended on whether people reported lower or higher personal norms to protect the climate. These results thus support the hypothesized moderating effect of personal norms for the influence of COVID-19 related changes in external factors for the transition toward sustainable mobility behavior postulated in H2.

*Moderating effects of personal norms on decreased intentions to fly*

In the low personal norm group, the examined external factors explained 15.8% of the variance of participants’ decreased intentions

**Table 3**

Results of multiple regression analyses of the external factors (independent variables) on higher frequencies of use of bikes during periods of COVID-19 restrictions (April – June 2020) compared to the same period in 2019 (dependent variable) – depending on personal norms to protect the climate.

Personal norms to protect the climate	N	Explained variance	Independent variables	$\beta$	p
Low	1090	29.8%	Age	-0.06	< 0.03*
			Gender	0.04	n.s.
			Education	0.06	< 0.03*
			Perceived ease-of-bike use	0.22	< 0.001***
			Perceived safety in traffic	-0.05	n.s.
			Fewer cars	-0.03	n.s.
			Perception of others riding the bike	0.11	< 0.01**
			More bike paths available	-0.01	n.s.
			More time	0.07	< 0.05*
			Destinations in close proximity	0.33	< 0.001***
			Age	-0.03	n.s.
			Gender	0.02	n.s.
			Education	0.05	n.s.
High	1317	33.0%	Perceived ease-of-bike use	0.18	< 0.001***
			Perceived safety in traffic	0.07	< 0.02*
			Fewer cars	-0.04	n.s.
			Perception of others riding the bike	0.04	n.s.
			More bike paths available	0.06	n.s.
			More time	0.14	< 0.001***
			Destinations in close proximity	0.28	< 0.001***

to fly in 2020 compared to 2019. Apart from significant influences of the sociodemographic features and the perceived ease-of-flight avoidance that were again controlled for, the strongest effect was found for “fear of not getting home from a foreign country” ( $\beta = 0.19, p < .001$ ). Furthermore, we found significant effects of “costs to travel far are too high” ( $\beta = -0.10, p < .01$ ), “travel insurance and health insurance abroad” ( $\beta = 0.08, p < .05$ ) and of “perceived safety in Germany” ( $\beta = 0.06, p < .05$ ; see Table 4 for an overview).

In the high personal norm group, the examined external factors explained only 12.6% of the variance in participants’ decreased intentions to fly in 2020 compared to 2019. Apart from significant influences of the sociodemographic features and perceived ease-of-flight avoidance that were again controlled for, strongest effects were found for “difficulties to plan trips long-term” ( $\beta = 0.11, p < .01$ ) and “supporting the German tourism sector” ( $\beta = 0.11, p < .01$ ; see Table 4 for an overview).

Altogether, results show that both effect size pattern and number of significant predictors of the decreased intentions to fly in 2020 compared to 2019 depended on participants’ personal norm to protect the climate, thus also supporting H2 on the moderating effect of personal norms for the influence of COVID-19 related changes in external factors for the transition toward sustainable mobility behavior.

#### *Intended daily and travel mobility for the next 12 months depending on personal norms*

Participants in the low personal norm group indicated significantly different intended frequencies of use for the transport modes assessed for the next 12 months compared to the frequency of use they reported for the past 12 months (see Table 5 for an overview). Participants reported higher intentions to use the bike in the next 12 months compared to the last 12 months ( $Z = 16.91, p < .001$ ), as well as higher intentions to fly ( $Z = 4.536, p < .001$ ). Their intentions to use the car ( $Z = -5.534, p < .001$ ) and public transport ( $Z = -2.728, p < .01$ ) in the next 12 months however decreased compared to their reported use within the last 12 months. Against this background, H3a was partially supported by the data.

In the high personal norm group, we found two significant differences: Participants reported to intend to use the bike significantly more frequently ( $Z = 18.185, p < .001$ ) and the car significantly less frequently ( $Z = -11.604, p < .001$ ) in the next 12 months compared to the past 12 months. With regard to the frequencies of intended use of

public transport and planes, no significant differences were found. Thus, H3b was partially supported by the data.

#### **Discussion**

The present study examined the potential of COVID-19 and its associated political restrictions as a window of opportunity for the transition toward sustainable mobility in Germany. For a first overview, we studied direct impacts of COVID-19 restrictions on Germans’ daily and travel mobility via retrospective measures (RQ1a). We explored potential effects of COVID-19 restrictions on participants’ wishes for future mobility by comparing data from the present study with data collected in 2019 in a comparable sample of German citizens (RQ1b).

In addition, we further examined psychological mechanisms potentially moderating these direct effects of COVID-19 restrictions on peoples’ daily and travel mobility. We investigated effects of COVID-19 related changes in external factors on the transition of mobility behavior toward sustainability, and the potential moderating effect of personal norms to protect the climate (RQ2). Finally, we also examined the moderating role of personal norms to protect the climate on participants’ intentions for daily and travel mobility in post-COVID-19-times (RQ3).

#### *Evaluation of results and practical implications*

##### *Direct impacts of COVID-19 restrictions on daily and travel mobility*

In line with other studies (see, e.g., Allgemeiner Deutscher Fahrrad-Club, 2020; Dahlberg et al., 2020; Muhammad et al., 2020), our data paint a non-surprising picture of an overall reduced daily mobility reported across almost all modes of transport (except for walking, see below for details). The significant positive differences in the frequency of use of car, bike, public transport, long distance train (Deutsche Bahn), remote bus, carsharing, and plane, represent a higher frequency of use of these modes of transport in pre-COVID-19-times compared to the period of COVID-19 restrictions (April – June 2020) in Germany. This reduction in daily mobility does not come as a surprise given how the national lockdown, contact reduction measures, constraints in the cultural sector, and changes in family and working life decreased the need for and hindered mobility during the months of April to June 2020 in Germany.

The only significant negative difference in the reported usage between pre-COVID-19-times and periods of COVID-19 restrictions

**Table 4**

Results of multiple regression analyses of the external factors (independent variables) on participants' decreased intention to fly in 2020 compared to 2019 (dependent variable) – depending on personal norms to protect the climate.

Personal norms to protect the climate	N	Explained variance	Independent variables	$\beta$	p			
Low	1030	15.8%	Age	0.04	n.s.			
			Gender	-0.02	n.s.			
			Education	0.05	n.s.			
			Perceived ease-of-flight avoidance	0.22	< 0.001***			
			Attractive travel destinations nearby / in Germany	0.01	n.s.			
			Perceived safety in Germany	0.06	< 0.05*			
			Financial risks of travelling far	0.07	n.s.			
			Supporting the German tourism sector	0.03	n.s.			
			Difficulties to plan trips long-term	0.04	n.s.			
			Fear of not getting home from a foreign country	0.19	< 0.001***			
			Costs to travel far are too high	-0.10	< 0.01**			
			Travel insurance and health insurance abroad	0.08	< 0.02*			
			High	1236	12.6%	Age	0.07	< 0.03*
						Gender	-0.01	n.s.
Education	0.04	n.s.						
Perceived ease-of-flight avoidance	0.21	< 0.001***						
Attractive travel destinations nearby / in Germany	- 0.07	< 0.04*						
Perceived safety in Germany	0.03	n.s.						
Financial risks of travelling far	0.10	< 0.01**						
Supporting the German tourism sector	0.11	< 0.01**						
Difficulties to plan trips long-term	0.11	< 0.01**						
Fear of not getting home from a foreign country	0.07	n.s.						
Costs to travel far are too high	-0.02	n.s.						
Travel insurance and health insurance abroad	-0.01	n.s.						

**Table 5**

Comparisons of frequencies of use of transport modes for daily and travel mobility between the past 12 months and the intended frequencies of use in the next 12 months – depending on personal norms to protect the climate.

Personal norms to protect the climate	N	Type of Transport	Difference between intended frequencies of use for the next 12 months – frequencies of use during the past 12 months		Z	p
			Amount of positive differences	Amount of negative differences		
Low	1437	Bike	431	44	16.91	< 0.001***
		Car	91	210	- 5.534	< 0.001***
		Public transport	167	209	- 2.728	< 0.01**
		Plane	289	169	4.536	< 0.001***
High	1593	Bike	516	45	18.185	< 0.001***
		Car	79	340	- 11.604	< 0.001***
		Public transport	280	241	1.375	< 0.17
		Plane	312	259	1.403	< 0.16

(April – June 2020) was found for walking. Participants walked *more* frequently in the months of April to June 2020 compared to before. This goes in line with previous research, e.g., from the [Allgemeiner Deutscher Fahrrad-Club \(2020\)](#), that shows an increase in walking during times of COVID-19 restrictions. This increase found in walking does not contradict the overall reduced mobility shown above and the depicted tendencies in transitions toward sustainable mobility. In times of COVID-19 restrictions, people stayed within smaller radiuses, therefore in walking distance, and covered smaller distances (e.g., [Warren & Skillman, 2020](#)). Additionally, people had more time at hand (due to, e.g., short time), and could therefore use the slower transport mode of walking, alongside with walking for leisure purposes. This is, e.g., supported by a study from [Muhammad et al. \(2020\)](#), that showed an increase in presence in parks etc. in Germany during times of COVID-19 restrictions. One very important explanation for the increased popularity of walking (and other individual transport modes) is the fact that it provides people with a safer way to get around because of lower infection risks. Walking could therefore have served as an alternative for shared transport modes, e.g., public transport.

In contrast to other surveys (e.g., [Kanda & Kivimaa, 2020](#)) and objective mobility data ([Allgemeiner Deutscher Fahrrad-Club, 2020](#); [Köln, 2020](#)) our Germany-wide data did not show an increase in bike usage during periods of COVID-19 restrictions (April – June 2020) in

Germany. However, as found in other studies (e.g., [Allgemeiner Deutscher Fahrrad-Club, 2020](#); [Heiler et al., 2020](#); [Krämer, 2020](#)), our results show that different transport modes were affected differently by the COVID-19 restrictions. The usage of planes decreased the most, followed by the usage of public transport. The two least affected transport modes were bikes and cars, with bike usage having decreased the least. This goes in line with other studies ([Allgemeiner Deutscher Fahrrad-Club, 2020](#); [Heiler et al., 2020](#); [Krämer, 2020](#)), showing a relative decrease in the use of shared mobility like public transport, and a relative increase in individual mobility, as car and bike use as well as walking. This is partly due to a higher perceived risk of infection in shared transport modes.

#### Similar wishes for future mobility despite COVID-19 restrictions

We found similar patterns of wishes for future mobility in our study compared to a study from 2019, which had been conducted shortly before COVID-19 restrictions were implemented in Germany ([Acatech, 2019](#)). However, several of the absolute frequencies of wishes selected differed between the two surveys. These differences can to some extent result from COVID-19 restrictions. Participants in the present study reported lower wishes to be less mobile, hence they wished to be more mobile than before the pandemic. Given the



enforced mobility reductions, this result was not surprising. Still, we did not find empirical evidence for (over-)compensating and unsustainable mobility tendencies as assumed by other researchers (e.g., de Haas et al., 2020) in future mobility wishes, e.g., wishes/intentions for increased travel mobility by plane in post-COVID-19-times. Instead, our results rather indicate a tendency toward more sustainable mobility. This assumption is supported by the increased wish to move around more environmentally friendly, higher intentions to walk and to use the bike, and the increased wish to fly less in the present study compared to 2019. Altogether, these findings suggest a first cautious interpretation of the COVID-19 and its associated political restrictions as a window of opportunity for the transition toward a sustainable mobility.

#### *Moderating effects of personal norms on changes in daily and travel mobility*

Previous research shows that great disruptions often lead to a change in behavioral contexts/ external factors that determine behaviors, and thus allow for habits to be broken up and reconsidered (e.g., Klöckner & Matthies, 2004). The COVID-19 restrictions represent such a great disruption and hence a window of opportunity for changes in so far highly habitualized mobility behaviors. Studies on the psychology of transport mode choice show that such changes of external factors can result in long-term behavior changes, especially if the person already expressed high personal norms in favor of these changes beforehand and makes positive experiences through the changed behaviors (Lattarulo et al., 2019; Matthies et al., 2006). Such disruptions can thus decrease the behavioral-determining effects of previous habits and increase the behavior-determining effect of normative factors like personal norms, such as the effect of personal norms to protect the climate on the transition toward sustainable mobility behavior.

With regard to these considerations, we examined the moderating role of personal norms to protect the climate on the effects of COVID-19 related changes in external factors on higher frequencies of bike use during periods of COVID-19 restrictions (April – June 2020) compared to the same period in 2019 and on decreased intentions to fly in 2020 compared to 2019.

#### **Direct effects of COVID-19 related changes in external factors on the transition toward sustainable mobility**

Our data show that the distance to the destination was the most important predictor for higher frequencies of bike use during periods of COVID-19 restrictions (April – June 2020) compared to the same period in 2019, both among participants with high as well as low personal norms to protect the climate. This aspect should be considered with regard to structural intervention approaches aiming at improving sustainability of the mobility sector, e.g., in urban spatial planning. Higher bike use frequencies in daily mobility could, for example, be achieved by building frequently used infrastructures in close proximity to (most) relevant consumer-groups (e.g., families with small children). In this context, there is promising empirical evidence on potential effects of minimal structural interventions on the promotion of sustainable daily mobility. A study in China, e.g., shows that increasing the perceived safety and comfort of sustainable modes of transport through minimal structural interventions (e.g., by considering the provision of bi-directional cycle ways), can be an effective strategy for the promotion of cycling, especially with regards to families with small children (see e. g., Chevalier & Charlemagne, 2020).

Our results also point out practical implications for potential structural changes and/ or political measures that could support the transition towards sustainable travel mobility. In the present study, expected financial risks associated with long-distance journeys and the fear of being stranded in a foreign country revealed to be important reasons

for a decreased intention to fly in 2020 compared to 2019. This implies that the demand for air travel is currently not only low because of travel bans, etc., but also because of higher perceived individual costs and risks (e.g., having to pay more for the governmental “Rückholaktion”). So, in order to further promote sustainable travel mobility, governments should internalize risks of flights and oblige the travelers to take on the associated actual costs. Alongside financial risks, environmental impacts of flying should also be integrated into the travelers’ costs.

#### **Moderating effects of personal norms on effects of COVID-19 related changes in external factors**

In addition to the direct effects of COVID-19 related changes in external factors on sustainable mobility changes, we also examined the moderating effects of personal norms to protect the climate in this process. Our study provides empirical evidence for the moderating effects of such personal norms in different contexts. External factors explained more variance in higher frequencies of bike use during periods of COVID-19 restrictions across participants with high personal norms to protect the climate than across participants with lower personal norms. This suggests that the importance of external factors for the behavior differs between the two groups. For example, the perception of having more time and a perception of feelings of secure were more relevant for people with higher personal norms to protect the climate than for people with lower personal norms. Since bike riding represents a type of daily mobility that is typically determined by strong mobility habits (see e.g., Aarts et al., 1997; Muñoz et al., 2013), these results indicate a moderating effect of personal norms. Although COVID-19 related changes in external factors affected the behavior across all participants, supported by significant effects of the examined external factors in both groups. However, more/ stronger effects were found for people with higher personal norms to protect the climate, which resulted in higher amounts of explained variance. The fact that COVID-19 related changes in external factors explained more variance among participants with higher personal norms suggests that these participants were more sensitive for changes in their behavioral contexts. These changes potentially reduced behavioral barriers for bike use, and allowed for their high personal norms to guide their action. These results are in line with previous studies on the psychology of transport mode choice that showed changes of external factors to result in long-term behavior changes, especially if the person already expressed high personal norms in favor of these changes and made positive experiences resulting from these changed behaviors (Lattarulo et al., 2019; Matthies et al., 2006).

However, when examining the moderating effects of personal norms on the effects of COVID-19 related changes in external factors on travel mobility (i.e., decreased intentions to fly in 2020 compared to 2019), result patterns were reversed to the ones of bike use. Travel mobility, and especially intended journeys by plane, should not be determined by strong habitualization, since this behavior is usually not performed every day as it is the case for daily transport mode choice behavior, for which in turn strong habitualization can be assumed (see e.g., Klöckner & Verplanken, 2019; Wood et al., 2002 for an overview). In line with this assumption, COVID-19 related changes in external factors should not affect the decreased intention to fly as strong as the travelers’ personal norms, since it is not a highly habitualized behavior. In contrast to effects of external factors, especially internal factors (e.g., personal norms to protect the climate, the attitude towards flying etc.) represent stronger predictors for environmentally relevant behaviors, which are not determined by strong habitualization (see e.g. Steg et al., 2019 for an overview on predictors of environmental relevant behaviors).

This is supported by our results, showing that external factors explained a smaller amount of variance in decreased intentions to fly in 2020 compared to 2019 among participants with higher personal

norms to protect the climate, and stronger effects of these external factors were found among participants with lower personal norms.

Taken together, these results further underpin our assumption that COVID-19 and its associated political restrictions could serve as a window of opportunity for the transition toward sustainable mobility with regards to strongly habitualized behaviors such as daily transport mode choices. COVID-19 does not only affect mobility behaviors directly through restrictions (see Section “Direct impacts of COVID-19 restrictions on daily and travel mobility” for details), but also indirectly via reinforcing the behavioral-determining effects of internal factors like personal norms to protect the climate.

#### *Moderating effects of personal norms on intended daily and travel mobility in post-COVID-19-times*

When comparing frequencies of use of transport modes for daily and travel mobility in pre-COVID-19-times with the intended use in post-COVID-19-times (i.e., in the next 12 months), our results provide further empirical evidence for the moderating effect of personal norms to protect the climate on the transition of mobility behavior toward sustainability. While some long-term behavioral change intentions toward sustainable daily mobility were found among all participants (e.g., the intention to use the bike more frequently and the car less frequently in post-COVID-19-times), other results suggest that intentions depend on the personal norms to protect the climate in other cases. Participants with lower personal norms, e.g., intended to use public transport less frequently in post-COVID-19-times compared to pre-COVID-19-times, and to fly more frequently. This difference was not found for participants with high personal norms to protect the climate, whose past and intended use of public transport and planes did not differ significantly. Thus, these results further support the already suggested moderating effect of personal norms on behavioral changes toward sustainable mobility in the context of COVID-19 restrictions.

#### *Limitations and implications for future research*

Altogether, the present study represents a very first step in researching the consequences of COVID-19 restrictions for the transition toward a (more) sustainable mobility in Germany. There are, of course, diverse limitations, which should be considered when interpreting the presented empirical findings. At the same time, these limitations point out relevant directions for future research, alongside our study's conclusions.

#### *Limitations for conclusions about causality*

Even though we tried to use a more robust research design to analyze behavioral changes using both retro- and prospective data as well as comparing our results to data from previous studies, final conclusions on causality cannot be made based on cross-sectional data. Ideally, an additional survey should be conducted examining potential long-term effects of the pandemic and its restrictions on peoples' daily and travel mobility (in Germany and beyond). To this end, a second study is planned by the authors for summer 2021 to provide longitudinal data on potential changes in Germany.

#### *Limitations referring to measures used in the present study*

There are a few limitations with regards to the measures used in this study that should be considered: (1) We did not measure actual behavior but relied on (retro- and prospective) self-reports, which can be issue to social desirability and memory biases (see e.g., [Nederhof, 1985](#); [Roy et al., 2005](#)). (2) Furthermore, for the sake of comparability with previous data (these comparisons were interpreted in a different publication, see [Matthies et al., 2020](#)), we had to

measure most mobility behaviors in the present study on an ordinal-scale level. This may have decreased the statistical power of the analyses, which we conducted for the investigation of our research questions and hypotheses. (3) It should also be considered that we did not measure all potentially relevant contextual factors/ control variables that could have provided further information, e.g., when assessing the effects of COVID-19 related changes in external factors on the transition toward sustainable mobility behavior, due to survey lengths. For example, we did neither explicitly assess car and bike availability nor work-related requirements to use the plane. Although we captured some cognitive variables (representing appropriate proxies for such contextual factors affecting daily transport as well as travel mode choices, see Section “The relevance of COVID-19 related changes in external factors for the transition toward sustainable mobility” for details), future studies should assess these potentially relevant contextual factors/ control variables directly. (4) Additionally, future studies should examine effects of further cognitive variables, which could be relevant moderators for individual behavioral changes toward or against sustainable mobility, that could not be assessed in the present study due to survey length. Examples for such cognitive variables would be people's perceived safety on roads, as well as potential health or environmental concerns with regards to COVID-19 and beyond.

#### *Limitations regarding the generalizability of the results*

Since our study was conducted in a sample of German citizens, and only studied impacts of the COVID-19 restrictions only in the specific time frame of April to June 2020, our findings are restricted to the German population as well as to this specific time period. Thus, the question arises, if our findings can be generalized to other populations as well as to other periods of COVID-19 restrictions (e. g., in spring/ summer 2021)?

In this context, it should be considered that rate of infection, death rates, etc. in relation to COVID-19, strongly differed between countries. For example, in the middle of June 2020, approximately 188 500 people were infected with COVID-19 in Germany. In contrast, infection rates were substantially higher in many other countries, like Spain (244 328) or Italy (237 500), while, for example, in China, infection rates were substantially lower at that time (84 422; [Ratke, 2021](#)). Furthermore, there were also relevant differences in COVID-19 restrictions between countries. As summarized by [Siewert and colleagues \(2020\)](#):

“[...] the German government was able to cope with the crisis better than most other large Western countries, including the United States, Great Britain, France, Italy, and Spain. In addition to ramping up health resources, federal and state governments introduced physical distancing measures, quarantine obligations for the infected, the closure of universities, schools, and daycare facilities, restrictions of mass gatherings [...], and a wide-ranging shutdown of businesses that were deemed “non-essential”. However, in comparison to France, Italy or Spain, restrictions were less harsh. For instance, in Germany people were generally allowed to exercise outside, go for a walk or shop for groceries with their partners and families – which was not possible in the countries that issued a comprehensive lockdown.”

Against this background, it seems rather improbable that our results can easily be generalized to other populations as well as to other periods of COVID-19 restrictions. Therefore, future research should consider this limitation by studying the potential the pandemic has to serve as a window of opportunity for the transition toward sustainable mobility in other populations and with regard to further periods of COVID-19 restrictions.

*Examining peoples’ perceptions of COVID-19 related behavioral changes toward sustainable mobility*

Although our study focused on behavioral changes toward sustainable mobility, we did not explicitly assessed participants’ perceptions of the behavioral changes in the context of sustainable mobility. Participants were asked to report their mobility behavior during times of COVID-19 restrictions and in pre-COVID-19-times, as well as their intended mobility behavior in post-COVID-19-times. We, however, did not examine whether participants considered their reported behavior/ changes in their mobility behavior as issues of sustainability. In this context, previous research already provided empirical evidence that people do not necessarily consider changes in their daily mobility patterns as issues of sustainability, although these changes represent transitions toward sustainable mobility (see e. g., [Chevalier et al., 2019](#), for an example). However, with regard to the effective promotion of sustainable mobility, it seems important that people do not consider changes in their pre-COVID-19 mobility routines in relation to COVID-19 restrictions. It is also important that people perceive their behavioral changes (also) in relation to the transition toward sustainable mobility. Otherwise, it seems rather unlikely that COVID-19-initiated behavioral changes will result in stable sustainable mobility routines in post-COVID-19 times. It thus seems indispensable that future research examines people’s perceptions of COVID-19-related behavioral changes in the context of the transition toward sustainability.

Altogether, it is obvious that more empirical studies are needed to provide solutions for the aforementioned limitations in order to further examine the potential of the pandemic and its associated political restrictions on the transition toward sustainable mobility.

**Conclusion**

Despite great negative societal consequences (see, e.g., [de Vos, 2020](#)), COVID-19 and its associated political restrictions yielded at least partly in (behavioral) changes toward sustainability and opened windows of opportunity for long-term behavioral changes. One of the sectors most affected by the pandemic and its restrictions was and still is the one of mobility. The mobility sector is, since accounting for 18.8% of the per capita CO<sub>2</sub>-emissions in Germany, crucial for the transition toward sustainability.

The present study allows for first empirical conclusions about the impacts of COVID-19 restrictions on German’s mobility behavior. We could show an overall reduction of mobility across almost all modes of transport for daily and travel mobility during periods of COVID-

19 restrictions compared to pre-COVID19-times, with different transport modes being affected differently. With regards to potential effects of COVID-19 restrictions on future mobility behavior, our study showed only few signs of compensating tendencies.

Furthermore, our findings point out the relevance of personal norms to protect the climate for the transition toward a sustainable mobility, both within and beyond the pandemic. In line with prior psychological studies on the impact of temporal disruptions on long-term behavioral changes, our study implies to treat the pandemic as a potential window of opportunity for the transition towards sustainable mobility.

**CRedit authorship contribution statement**

**Karolin Schmidt:** Conceptualization, Formal analysis, Investigation, Methodology, Validation, Writing - original draft. **Theresa Sieverding:** Conceptualization, Investigation, Methodology, Visualization, Writing - review & editing. **Hannah Wallis:** Conceptualization, Investigation, Methodology, Writing - review & editing. **Ellen Matthies:** Conceptualization, Investigation, Methodology, Supervision, Writing - review & editing, Funding acquisition, Project administration.

**Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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**Appendix A**

**Table A1**

Items assessing frequencies of use of different modes of transport for daily and travel mobility during several time periods.

Variable	Number of items	Items	Answer options
Daily mobility	8	Please think about the last three months [the last 12 months]. Please state how frequently you used following means of transport: Please think about the next 12 months. State how frequently you will use the following means of transport.	<ul style="list-style-type: none"> <li>• a bike</li> <li>• a car</li> <li>• a carsharing vehicle</li> <li>• a bus, tram, or train in your region</li> <li>• ways exclusively by foot</li> <li>• the train for single distances above 100 km</li> <li>• the bus for single distances above 100 km</li> </ul>
Travel mobility		Please think about the last three months [the last 12 months]. Please state how frequently you used a plane  Please think about the next 12 months. State how often you intend to take a plane.	<p>At least once a month; at least once every 2–6 month; at least every 6–12 month; less often; never</p> <p>At least once a month; at least once every 2–6 month; at least every 6–12 month; less often; never</p>

**Table A2**

Items assessing participants' wishes for future mobility based on the survey conducted by Acatech (2019).

Variable	Number of items	Items	Answer options
Wishes for future mobility	11	What would you like to change about your mobility?	<p>I would like to spend less money on my mobility.</p> <p>I would like to cover more distances walking or by bike.</p> <p>I would like to be on the move more environmentally friendly.</p> <p>I would like to be more flexible when I drive or go somewhere.</p> <p>I would like to use the car less often.</p> <p>I would like to be less on the move.</p> <p>I would like to use the time while I'm on the move in a more efficient way.</p> <p>I would like to spend less time in public transport.</p> <p>I would like to be less dependent on public transportation.</p> <p>I would like to fly less often.</p> <p>None of these reasons / I wouldn't change anything.</p>

**Table A3.1**

Items used to examine the effects of external factors possibly related to political COVID-19 restrictions on higher frequencies of bike use during times of COVID-19 restrictions (i.e., April – June 2020) compared to the same time period in 2019.

Variable	Number of items	Items	Answer options
Higher frequencies of bike use during times of COVID-19 restrictions (i.e., April – June 2020) compared to the same time period in 2019	1	To what extent do you agree with the following statements? During the last three months I have ridden the bike more than in the same period last year.	Do not agree at all (1) to completely agree (7), I don't know
Possible reasons for higher frequencies of bike use	8	<p>Here you find a list of possible reasons that could play a potential role to use the bike more often. Please state how the following reasons are relevant for you.</p> <ul style="list-style-type: none"> <li>• I felt safer on the streets.</li> <li>• There were fewer cars on the road.</li> <li>• Others used the bike more often as well.</li> <li>• I could use more bike paths.</li> <li>• The air quality was better.</li> <li>• I would like to be on the move more environmentally friendly.</li> <li>• I had more time at hand.</li> <li>• I drove more often to destinations in closer proximity.</li> </ul>	Do not agree at all (1) to completely agree (7), I don't know
Perceived ease-of-bike use	3	<ul style="list-style-type: none"> <li>• It is easy for me to use the bike instead of the car.</li> <li>• I made good experiences by taking the bike instead of the car.</li> <li>• I am confident that I can get many things done by using the bike instead of the car.</li> </ul>	Do not agree at all (1) to completely agree (7), I don't know

**Table A3.2**

Items used to examine the effects of external factors possibly related to political COVID-19 restrictions on decreased intentions to fly in 2020 compared to 2019.

Variable	Number of items	Items	Answer options
Decreased intentions to fly in 2020 compared to 2019	1	To what extent do you agree with the following statements? In comparison to 2019 I intend to fly less this year.	Do not agree at all (1) to completely agree (7), I don't know
Potential reasons for a decreased intention to fly	9	<p>Here you find a list of reasons that could play a potential role for flying less. Please state how the following reasons are relevant for you.</p> <ul style="list-style-type: none"> <li>• There are attractive travel destinations nearby / in Germany as well.</li> <li>• Long-distance travels seem financially too risky.</li> <li>• I would like to travel more environmentally friendly.</li> <li>• I want to support the German tourism sector.</li> <li>• Long-term planning of trips seems difficult to me.</li> <li>• I am afraid of being stranded in a foreign country with no guarantee to get back to Germany.</li> <li>• The prices for long-distance travel are too high.</li> <li>• I'm not sure whether I can take out a travel insurance / my travel health insurance would cover expenses abroad.</li> </ul>	Do not agree at all (1) to completely agree (7), I don't know
Perceived ease-of-flight avoidance	3	<ul style="list-style-type: none"> <li>• I can definitely imagine to avoid flying.</li> <li>• I am certain that I can travel without flying.</li> <li>• It is easy for me to give up flying.</li> </ul>	Do not agree at all (1) to completely agree (7), I don't know

Table A4

Items used to assess participants' personal norms to protect the climate.

Variable	Number of items	Items	Answer options
Personal norms to protect the climate	3	To which extent do you agree with the following statements? <ul style="list-style-type: none"> <li>Based on my personal values, I feel obligated to engage politically for the climate protection</li> <li>On the basis of my personal values, I feel obligated to contribute to the protection of the climate through my daily behavior.</li> <li>No matter what others expect from me, I feel obligated to contribute to climate protection by changing my lifestyle.</li> </ul>	Do not agree at all (1) to completely agree (7), I don't know

## References

- Aarts, H., Verplanken, B., van Knippenberg, A., 1997. Habit and information use in travel mode choices. *Acta Psychol.* 96 (1–2), 1–14. [https://doi.org/10.1016/s0001-6918\(97\)00008-5](https://doi.org/10.1016/s0001-6918(97)00008-5).
- Abu-Rayash, A., Dincer, I., 2020. Analysis of the electricity demand trends amidst the COVID-19 coronavirus pandemic. *Energy Res. Social Sci.* 68, 101682. <https://doi.org/10.1016/j.erss.2020.101682>.
- Neuburger, L., Egger, R., 2020. Travel risk perception and travel behaviour during the COVID-19 pandemic 2020: a case study of the DACH region. *Current Issues in Tourism* 24 (7). <https://doi.org/10.1080/13683500.2020.1803807>.
- Shamshiripour, A., Rahimi, E., Shabanpour, R., Mohammadian, A., 2020. How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago. *Transportation Research Interdisciplinary Perspectives* 7, 100216. <https://doi.org/10.1016/j.trip.2020.100216>.
- Acatech, 2019. Mobilität und Klimaschutz – Gesellschaftliches Problembewusstsein und individuelle Veränderungsspielräume. <https://www.acatech.de/publikation/mobilitaet-und-klimaschutz/>
- Allgemeiner Deutscher Automobil-Club, A., 2020. Corona und Mobilität: Mehr Homeoffice, weniger Berufsverkehr. <https://www.adac.de/verkehr/standpunkte-studien/mobilitaets-trends/corona-mobilitaet/>
- Allgemeiner Deutscher Fahrrad-Club, A., 2020. Handlungsempfehlungen für Kommunen. Bleibt alles anders: Corona und der (Rad-)Verkehr. [https://repository.difu.de/jspui/bitstream/difu/576396/1/Handlungsleitfaden\\_fuer\\_Kommunen.pdf](https://repository.difu.de/jspui/bitstream/difu/576396/1/Handlungsleitfaden_fuer_Kommunen.pdf).
- Anke, J., Schaefer, L.-M., Francke, A., 2020. Befragung: Wie verändert Corona unsere Mobilität langfristig? [https://tu-dresden.de/bu/verkehr/ivs/vpsy/forschung/corona-mobilitaet/set\\_language=de](https://tu-dresden.de/bu/verkehr/ivs/vpsy/forschung/corona-mobilitaet/set_language=de).
- Bundesministerium für Verkehr und digitale Infrastruktur, 2020. Mobilität in Deutschland. <https://www.bmvi.de/SharedDocs/DE/Artikel/G/mobilitaet-in-deutschland.html>.
- Bamberg, S., 2012. Understanding and promoting bicycle use—insights from psychological research.. In: Parkin, J. (Ed.), *Cycling and Sustainability*. Emerald.
- Cannon, C., Goldsmith, K., Roux, C., 2019. A Self-Regulatory Model of Resource Scarcity. *J. Consumer Psychol.* 29 (1), 104–127. <https://doi.org/10.1002/jcpsy.1035>.
- Chevalier, A., Charlemagne, M., 2020. When connectivity makes safer routes to school: Conclusions from aggregate data on child transportation in Shanghai. *Transp. Res. Interdisciplinary Perspectives* 8, 100267. <https://doi.org/10.1016/j.trip.2020.100267>.
- Chevalier, A., Charlemagne, M., Xu, L., 2019. Bicycle acceptance on campus: Influence of the built environment and shared bikes. *Transp. Res. Part D: Transport Environ.* 76, 211–235. <https://doi.org/10.1016/j.trd.2019.09.011>.
- Chng, S., Abraham, C., White, M.P., Hoffmann, C., Skippon, S., 2018. Psychological theories of car use: An integrative review and conceptual framework. *J. Environ. Psychol.* 55, 23–33. <https://doi.org/10.1016/j.jenvp.2017.10.009>.
- Dahlberg, M., Edin, P.-A., Grönqvist, E., Lyhagen, J., Östh, J., Siretskiy, A., Toger, M., 2020. Effects of the COVID-19 Pandemic on Population Mobility under Mild Policies: Causal Evidence from Sweden.
- Fahrrad-Monitor Deutschland, 2019. Ergebnisse einer repräsentativen Online-Befragung. [https://www.bmvi.de/SharedDocs/DE/Anlage/K/fahrradmonitor-2019-ergebnisse.pdf?\\_\\_blob=publicationFile](https://www.bmvi.de/SharedDocs/DE/Anlage/K/fahrradmonitor-2019-ergebnisse.pdf?__blob=publicationFile).
- Fujii, S., Gärling, T., Kitamura, R., 2001. Changes in Drivers' Perceptions and Use of Public Transport during a Freeway Closure: Effects of Temporary Structural Change on Cooperation in a Real-Life Social Dilemma. *Environ. Behavior* 33 (6), 796–808. <https://doi.org/10.1177/00139160121973241>.
- Gliem, J. A., Gliem, R. R., 2003. Calculating, Interpreting, and Reporting Cronbach's Alpha Reliability Coefficient For Likert-Type Scales. <http://scholarworks.iupui.edu/handle/1805/344>
- Haas, M. de, Faber, R., Hamersma, M., 2020. How COVID-19 and the Dutch 'intelligent lockdown' change activities, work and travel behaviour: Evidence from longitudinal data in the Netherlands. *Transportation Research Interdisciplinary Perspectives*, 6, 100150. <https://doi.org/10.1016/j.trip.2020.100150>
- Harland, P., Staats, H., Wilke, H.A.M., 1999. Explaining Proenvironmental Intention and Behavior by Personal Norms and the Theory of Planned Behavior. *J. Appl. Soc. Psychol.* 29 (12), 2505–2528. <https://doi.org/10.1111/j.1559-1816.1999.tb00123.x>.
- Heiler, G., Reisch, T., Hurt, J., Forghani, M., Omani, A., Hanbury, A., & Karimipour, F. (2020). Country-wide mobility changes observed using mobile phone data during COVID-19 pandemic.
- Hunecke, M., Blöbaum, A., Matthies, E., Höger, R., 2001. Responsibility and Environment: Ecological Norm Orientation and External Factors in the Domain of Travel Mode Choice Behavior. *Environment and Behavior* 33, 830–852. <https://doi.org/10.1177/00139160121973269>.
- Kanda, W., Kivimaa, P., 2020. What opportunities could the COVID-19 outbreak offer for sustainability transitions research on electricity and mobility?. *Energy Res. Social Sci.* 68, 101666. <https://doi.org/10.1016/j.erss.2020.101666>.
- Klößner, C.A., Matthies, E., 2004. How habits interfere with norm directed behavior - A normative decision-making model for travel mode choice. *J. Environ. Psychol.* 24, 319–327.
- Klößner, C.A., Matthies, E., 2012. Two Pieces of the Same Puzzle? Script-based Car Choice Habits Between the Influence of Socialization and Past Behavior. *J. Appl. Soc. Psychol.* 42 (4), 793–821. <https://doi.org/10.1111/j.1559-1816.2011.00817.x>.
- Klößner, C. A., Verplanken, B., 2019. Yesterday's habits preventing change for tomorrow? The influence of automaticity on environmental behaviour. In L. Steg, A. van den Berg, & de Groot, J. I. M. (Eds.), *Environmental psychology: An introduction* (pp. 197–209). Wiley-Blackwell.
- Kramer, A., Kramer, K.Z., 2020. The potential impact of the Covid-19 pandemic on occupational status, work from home, and occupational mobility. *J. Vocat. Behav.* 119, 103442. <https://doi.org/10.1016/j.jvb.2020.103442>.
- Krämer, A., 2020. Mobilität nach der Corona-Krise. Die Karten werden neu gemischt – Bestimmungsfaktoren für die Entwicklung der Gesamtmobilität sowie der relativen Wettbewerbsposition der Verkehrsträger. *Internationales Verkehrswesen* 3, 89–93.
- Kunst, A. (2017). Umfrage zur Verkehrsmittel-Nutzungshäufigkeit in Deutschland 2017. <https://de.statista.com/statistik/daten/studie/5761/umfrage/vorwiegend-genutzte-verkehrsmittel/>
- Kunst, A., 2020. Deutschland: Besitz eines Pkw 2020. <https://de.statista.com/prognosen/999770/deutschland-besitz-eines-pkw>.
- Lattarulo, P., Masucci, V., Paziienza, M.G., 2019. Resistance to change: Car use and routines. *Transp. Policy* 74, 63–72. <https://doi.org/10.1016/j.tranpol.2018.11.013>.
- Le Quéré, C., Jackson, R.B., Jones, M.W., Smith, A.J.P., Abernethy, S., Andrew, R.M., De-Gol, A.J., Willis, D.R., Shan, Y., Canadell, J.G., Friedlingstein, P., Creutzig, F., Peters, G.P., 2020. Temporary reduction in daily global CO<sub>2</sub> emissions during the COVID-19 forced confinement. *Nat. Clim. Change* 10 (7), 647–653. <https://doi.org/10.1038/s41558-020-0797-x>.
- Matthies, E., Klößner, C.A., Preisner, C.L., 2006. Applying a Modified Moral Decision Making Model to Change Habitual Car Use: How Can Commitment be Effective?. *Appl. Psychol.* 55 (1), 91–106. <https://doi.org/10.1111/j.1464-0597.2006.00237.x>.
- Matthies, E., Sieverding, T., Schmidt, K., Wallis, H., 2020. Stärken die Corona-Maßnahmen den dringend notwendigen Wandel zu einer nachhaltigen Mobilität und einer stärker regulierenden Klimaschutzpolitik?. Eine parallele Querschnitterhebung zu Mobilitätsverhalten und Politikunterstützung drei Monate nach Beginn der Krise. [http://www.ipsy.ovgu.de/ipsy\\_media/umweltsychologie/Matthies+et+al+2020-p-3266.pdf](http://www.ipsy.ovgu.de/ipsy_media/umweltsychologie/Matthies+et+al+2020-p-3266.pdf).
- Muhammad, S., Long, X., Salman, M., 2020. Covid-19 pandemic and environmental pollution: A blessing in disguise?. *Sci. Total Environ.* 728, 138820. <https://doi.org/10.1016/j.scitotenv.2020.138820>.
- Muñoz, B., Monzon, A., Lois, D., 2013. Cycling Habits and Other Psychological Variables Affecting Commuting by Bicycle in Madrid, Spain. *Transp. Res. Record: J. Transp. Res. Board* 2382 (1), 1–9. <https://doi.org/10.3141/2382-01>.
- Nederhof, A.J., 1985. Methods of coping with social desirability bias: A review. *Eur. J. Social Psychol.* 15 (3), 263–280. <https://doi.org/10.1002/ejsp.2420150303>.
- Nielsen, K. S., Clayton, S., Stern, P. C., Dietz, T., Capstick, S., Whitmarsh, L., 2020. How psychology can help limit climate change. *American Psychologist*. Advance online publication. 10.1037/amp0000624.
- Ratke, R., 2021. Entwicklung der weltweiten Fallzahl des Coronavirus (COVID-19) in 2021. <https://de.statista.com/statistik/daten/studie/1094950/umfrage/entwicklung-der-weltweiten-fallzahl-des-coronavirus/>
- Roy, M. M., Christenfeld, N. J. S., McKenzie, C. R. M., 2005. Underestimating the Duration of Future Events: Memory Incorrectly Used or Memory Bias? *Psychological Bulletin*, 131(5), 738–756. <https://doi.org/10.1037/0033-2909.131.5.738>.

- Siewert, M., Wurster, S., Messerschmidt, L., Cheng, C., Buthe, T., 2020. A German Miracle? Crisis Management During the COVID-19 Pandemic in a Multi-Level System. 10.2139/ssrn.3637013
- Stadt Köln, 2020. Radverkehr nimmt zu, Kfz-Verkehr nimmt ab. <https://www.stadt-koeln.de/politik-und-verwaltung/presse/mitteilungen/21712/index.html>.
- Statistisches Bundesamt, 2020a. Bevölkerung (ab 15 Jahren): Deutschland, Jahre, Geschlecht, Altersgruppen, Allgemeine Schulausbildung. <https://www-genesis.destatis.de/genesis/online?operation=abrufabelleBearbeiten&levelindex=1&levelid=1597236231177&auswahloperation=abrufabelleAuspraegungAuswaehlen&auswahlverzeichnis=ordnungsstruktur&auswahlziel=werteabruf&code=122110040&auswahltext=&werteabruf=starten#abreadcrumb>.
- Statistisches Bundesamt, 2020b. Bevölkerung nach Geschlecht und Staatsangehörigkeit. <https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsstand/Tabellen/zensus-geschlecht-staatsangehoerigkeit-2019.html>.
- Statistisches Bundesamt, 2020c. Durchschnittsalter nach Geschlecht und Staatsangehörigkeit 2011 bis 2019. <https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsstand/Tabellen/durchschnittsalter-zensus-jahre.html>.
- Statistisches Bundesamt, 2021. Nettoeinkommen privater Haushalte nach Haushaltstyp. [https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/\\_Grafik/\\_Interaktiv/einnahmen-ausgaben-haushaltstypen.html](https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/_Grafik/_Interaktiv/einnahmen-ausgaben-haushaltstypen.html).
- Steg, L., van den Berg, A., & de Groot, J. I. M. (Eds.). (2019). *Environmental psychology: An introduction*. Wiley-Blackwell.
- Stern, P. C., 2000. New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behavior. *Journal of Social Issues*, 56(3), 407–424. 10.1111/0022-4537.00175
- Umweltbundesamt, 2020. Konsum und Umwelt: Zentrale Handlungsfelder. <https://www.umweltbundesamt.de/themen/wirtschaft-konsum/konsum-umwelt-zentrale-handlungsfelder#umweltrelevanz-und-prioritaere-bedarfsfelder>
- Umweltbundesamt, 2021. Fahrleistungen, Verkehrsleistungen und Modal Split“. <https://www.umweltbundesamt.de/daten/verkehr/fahrleistungen-verkehrsaufwand-modal-split#fahrleistung-im-personen-und-guterverkehr>.
- Verplanken, B., & Roy, D., 2016. Empowering interventions to promote sustainable lifestyles: Testing the habit discontinuity hypothesis in a field experiment. *Journal of Environmental Psychology*, 45, 127–134. 10.1016/j.jenvp.2015.11.008
- de Vos, J., 2020. The effect of COVID-19 and subsequent social distancing on travel behavior. *Transportation Research Interdisciplinary Perspectives*, 5, 100121. 10.1016/j.trip.2020.100121.
- Warren, M. S., & Skillman, S. W., 2020. Mobility Changes in Response to COVID-19.
- Wood, W., Quinn, J. M., & Kashy, D. A., 2002. Habits in everyday life: Thought, emotion, and action. *Journal of Personality and Social Psychology*, 83(6), 1281–1297. 10.1037/0022-3514.83.6.1281