



## Gender differences in noise concerns about civil drones

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### ABSTRACT

Rapid technological developments provide people with an increasing number of opportunities for applying civil drones (e.g., rescue operations). However, one crucial aspect for the future use of drones will be their public acceptance. Importantly, drone acceptance is considered to substantially rely on noise concerns. Recent research demonstrated differences between certain groups of individuals (e.g., females vs. males) in their attitudes towards civil drones. By means of a representative telephone survey in Germany ( $n = 832$ ), we aimed at further investigating the influence of gender on drone acceptance. Chi-square Automatic Interaction Detection (CHAID) revealed noise concerns to be the most important of all assessed concerns for explaining female respondents' attitudes towards civil drones, while concerns about damages/injuries best explained male participants' attitudes. Moreover, our survey corroborates prior studies by showing males to be less concerned about civil drones than females (e.g., regarding noise). Additionally, we explored whether these effects could have been driven by confounding variables (e.g., drone experience). Thus, the present study highlights aspects of gender differences in concerns about drones which need to be examined further in future research.

### INTRODUCTION

There is an increasing interest in developing and applying civil drones for numerous purposes. For example, they are commonly expected to be game changers for applications such as rescue operations, agriculture, passenger transport ('air taxis'), parcel delivery, and medical tissue transport. However, besides several technological and legal challenges, one major obstacle to establishing civil drones in various areas of life will be the acceptance of these vehicles by potential users and society (see also [1]). Accordingly, people's general attitude towards this new technology has been assessed in several studies in recent years. In this context, representative surveys, which were conducted either online or via telephone, mostly revealed the respondents' general attitude towards civil drones to be either neutral or slightly positive on average (e.g. [2-4]; see also [5]). For instance, a representative online-survey of the German Unmanned Aviation Association (VUL) carried out in 2019 showed that 44% of the German population are rather positive about the application of drones for civil purposes, while 40% consider it rather negatively (16% undecided) [3].

In addition to rather general insights into the acceptance of civil drones, recent research also yielded empirical evidence that acceptance varies with certain sociodemographic factors. With respect to gender and age, males and younger adults were repeatedly shown to have a more positive general attitude towards civil drones than females and older adults (e.g. [2, 4]). For instance, a representative online-survey of the German Unmanned Aviation Association (VUL) conducted in 2017 revealed 54% of the male German population as compared to 31% of the female German population to be rather positive about the application of drones for civil purposes [2]. Correspondingly, prior research suggests that females frequently have more concerns about drone applications (e.g. [4]), for example regarding issues of privacy [6].

In 2018, the International Transport Forum (ITF) at the OECD postulated the potential impact on noise levels to be one of the major challenges for the future development and civil use of drones [7]. In line with this notion, previous research demonstrated noise originated from aviation (i.e., aircraft noise) to have particularly high potential for annoying citizens, for instance as compared to road traffic or railway noise (e.g. [8]). Last but not least, this is especially important because there is empirical evidence that noise has detrimental effects on people's health (for reviews, see [9, 10]). Hence, it seems to be surprising that several previous studies indicated concerns about drone noise to be among the least widespread of all assessed concerns on this topic (e.g. [2-4, 11, 12]; but see [13]). However, even though the prevalence of noise concerns was relatively low in the telephone-survey of Eißfeldt and colleagues, this recent study showed that whether participants had noise concerns about civil drones or not best explained the general attitude towards these vehicles among all considered concerns [4]. Importantly, this emphasizes the central role of noise concerns for future drone applications.

On this basis, the present study aimed at shedding further light not only on noise concerns about civil drones in general, but specifically on gender differences within this context. Additionally, we sought to examine to what extent potential gender differences could have been driven by certain confounding variables.

## METHODS

The present study was based on the same telephone-survey as the publication of Eißfeldt and colleagues [4]. The survey was carried out by infas (Institute for Applied Social Sciences, Bonn, Germany) in spring 2018 on behalf of the DLR German Aerospace Center. It consisted of computer-assisted telephone interviews (CATI) on the acceptance of civil drones in Germany with an average duration of 18 minutes per interview. A dual frame procedure with 70% landline numbers and 30% cell phone numbers was applied for generating telephone numbers. All participants were required to be at least 14 years of age and, for landline numbers, members of private households were selected by last-birthday procedure [14]. In this way, the sample comprised 832 respondents (48.2% females, 51.8% males) between 14 and 94 years ( $M = 51.5$  years,  $SD = 18.2$  years).

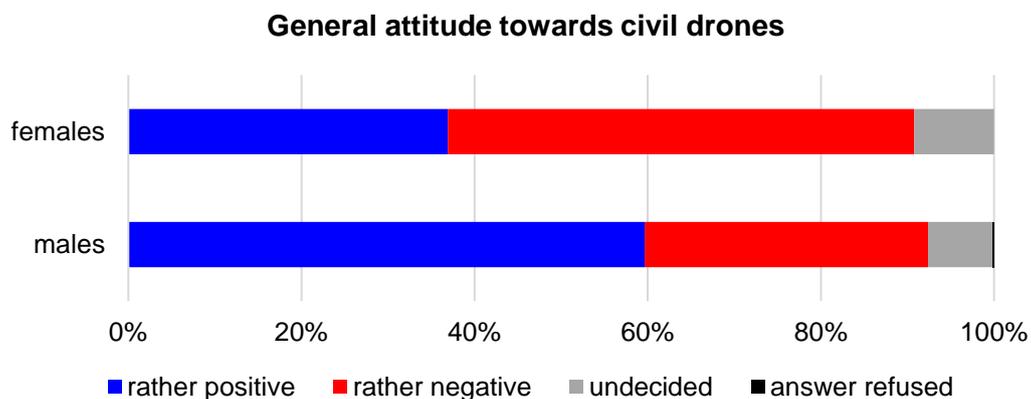
All findings reported in the 'results' section below refer to the original (i.e., raw) survey data because several analyses required data on the individual level of actual respondents. However, the 'results' section is completed by an explicitly labelled report of data that were weighted to ensure representativeness for the German population with respect to a number of central sociodemographic factors. In this way, it is ensured that the current study's two main findings on the superordinate group level were similar when using weighted as compared to unweighted survey data. The weighting was based on data of the German government

statistics and performed by infas with respect to age, gender, size of household, highest school degree, employment situation, federal state of residence, and community size [14]. For further information about the survey procedure as well as an overview of the general results, see the publication of Eißfeldt and colleagues [4].

## RESULTS

### Gender differences in general attitude towards civil drones

First, when asking the participants whether their general attitude towards civil drones was rather positive or rather negative, we found a significant gender difference,  $\chi^2(2) = 44.50$ ,  $p < .001$ . Whereas the majority of males reported to have a rather positive attitude towards drones (59.6% rather positive, 32.7% rather negative, 7.4% undecided, 0.2% answer refused), most females evaluated this technology rather negatively (36.9% rather positive, 53.9% rather negative, 9.2% undecided; see also Figure 1).<sup>1</sup>



**Figure 1:** Female and male respondents' general attitude towards civil drones.

### Explaining females' and males' general attitudes by concerns

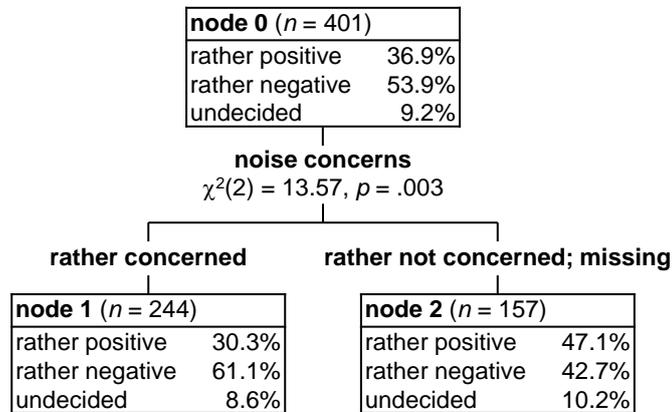
Second, we aimed at investigating the potential of the following seven assessed areas of concern about civil drones in explaining female and male respondents' general attitude: concerns about noise, concerns about damages and injuries, concerns about liability and insurance, concerns about the violation of privacy, concerns about crime and misuse, concerns about animal welfare, and concerns about traffic safety. To avoid sequence effects, the participants were asked whether they are rather concerned or rather not concerned about each of these areas in a randomized order. On this basis, for the purpose of analyzing which of the seven assessed areas of concern explained the participants' general attitude towards civil drones best, we calculated gender-specific Chi-square Automatic Interaction Detection (CHAID) models (see Figure 2).

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<sup>1</sup> Please note that even though 'refused' answers were excluded from the inferential statistical analysis of general attitudes towards civil drones, the corresponding percentages of these answers are reported for reasons of transparency.

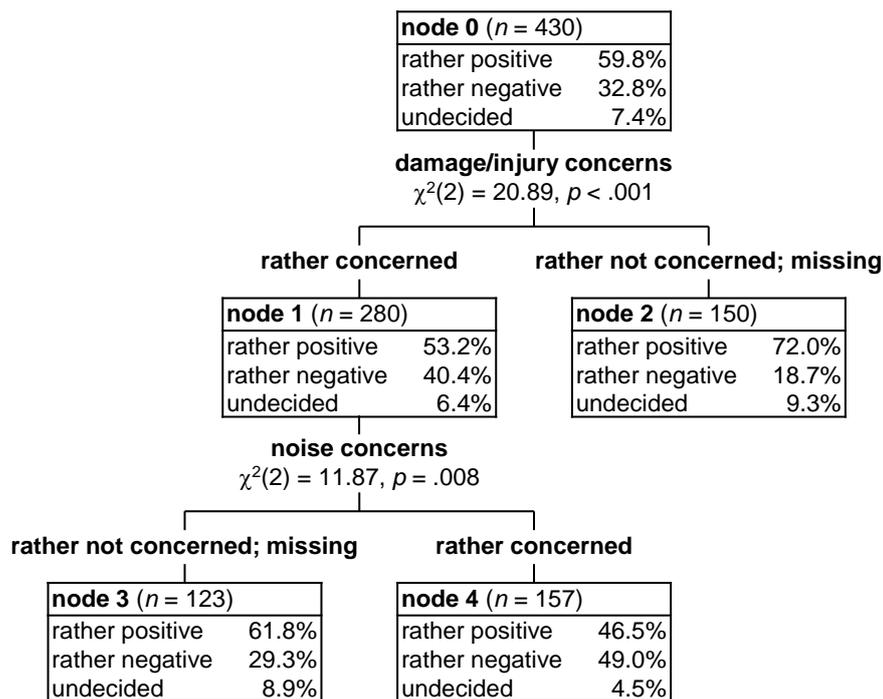
A)

**Females' general attitude  
 towards civil drones**



B)

**Males' general attitude  
 towards civil drones**



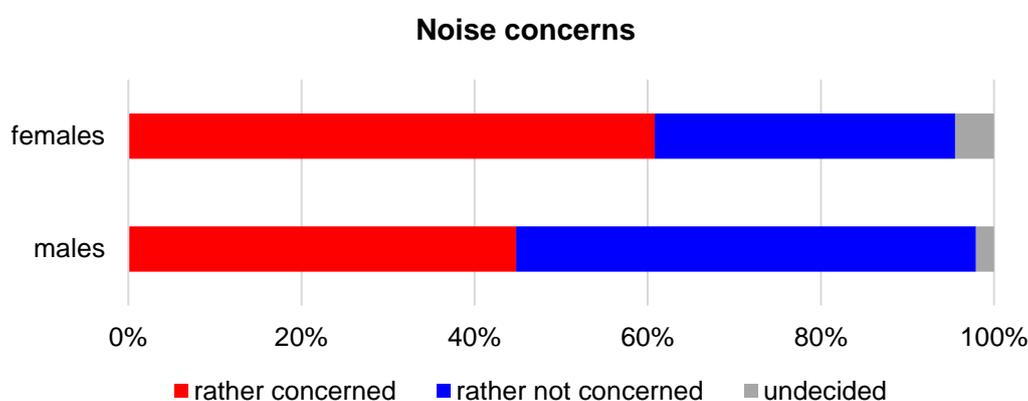
**Figure 2:** Gender-specific CHAID models. Note: Bonferroni-corrected *p*-values.

Importantly, concerns about noise constituted the only area of concern which significantly contributed to the explanation of female respondents' attitudes,  $\chi^2(2) = 13.57$ , Bonferroni-corrected  $p = .003$ . In contrast, concerns about damages and injuries explained male participants' attitudes best and entered the corresponding decision tree model on the first

level,  $\chi^2(2) = 20.89$ , Bonferroni-corrected  $p < .001$ . Only on the second level of the model, for male respondents who reported to be rather concerned about damages and injuries, concerns about noise made a significant further contribution to explaining the general attitude towards civil drones,  $\chi^2(2) = 11.87$ , Bonferroni-corrected  $p = .008$ .

### Gender differences in concerns

Third, in addition to the analysis of CHAID models, we examined whether the seven areas of concern were differentially widespread among female and male respondents. Importantly, this approach revealed a significant gender difference with respect to the prevalence of concerns about drone noise,  $\chi^2(1) = 26.14$ ,  $p < .001$ , indicating that females (60.8% rather concerned, 34.7% rather not concerned, 4.5% undecided) as compared to males (44.8% rather concerned, 53.1% rather not concerned, 2.1% undecided) more frequently reported to have noise concerns (see also Figure 3).<sup>2</sup>



**Figure 3:** Female and male participants' concerns about drone noise.

Apart from noise concerns, significant gender differences were found regarding five out of the six other areas of concern. In detail, female respondents reported more frequently than males to be concerned about damages and injuries,  $\chi^2(1) = 20.08$ ,  $p < .001$ , the violation of privacy,  $\chi^2(1) = 9.79$ ,  $p = .002$ , crime and misuse,  $\chi^2(1) = 15.05$ ,  $p < .001$ , animal welfare,  $\chi^2(1) = 37.26$ ,  $p < .001$ , and traffic safety,  $\chi^2(1) = 11.51$ ,  $p < .001$ . Only with respect to concerns about liability and insurance, there was no significant gender difference,  $\chi^2(1) = 1.65$ ,  $p = .20$ .

### Potential confounds of gender differences in noise concerns

Fourth, using the example of concerns about drone noise, we explored to what extent the reported gender differences could have been driven by confounding variables such as drone experience. Participants were asked whether they already had private or professional experience with civil drones. For data analysis, all answers indicating prior experience (i.e.,

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<sup>2</sup> Please note that even though 'undecided' as well as 'refused' answers were excluded from this and all following inferential statistical analyses whenever these answers occurred, the corresponding percentages of these answers are reported for reasons of transparency.

'yes, private experience', 'yes, professional experience', and 'yes, private as well as professional experience') were collapsed and contrasted with the answer 'no prior experience'. This analysis revealed a significant gender difference,  $\chi^2(1) = 10.92$ ,  $p < .001$ . Whereas the majority of males reported to have prior experience with drones (52.0% with prior experience, 47.8% without prior experience, 0.2% undecided), most females indicated to have no prior drone experience (40.6% with prior experience, 59.4% without prior experience). This marked drone experience as a potential confounding variable for the gender difference in noise concerns reported above. Hence, we subsequently examined whether the gender difference in noise concerns, in fact, could have been driven by the gender difference in drone experience. For this purpose, the existence of gender differences in noise concerns was tested, separately for respondents with and without prior drone experience. There were significant gender differences in concerns about drone noise, both for participants with prior drone experience,  $\chi^2(1) = 17.28$ , Bonferroni-corrected  $p < .001$ , as well as for respondents without such prior experience,  $\chi^2(1) = 9.13$ , Bonferroni-corrected  $p = .005$ . Both effects represented that females as compared to males more frequently reported to have noise concerns. Thus, even when controlling for the existence of drone experience, we found significant gender differences in noise concerns.

In the same way as for drone experience, we investigated whether the level of previous knowledge about civil drones could have been a confounding variable for the gender difference in noise concerns. When participants were asked to rate on a four-point Likert scale how well they felt informed about civil drones in general, we found a significant gender difference,  $\chi^2(3) = 42.57$ ,  $p < .001$ . The two categories indicating feeling rather informed were chosen more frequently by males as compared to females ('feeling very well informed': 16.2% of males, 6.7% of females; 'feeling somewhat informed': 45.9% of males, 34.9% of females), while the pattern was reversed for the two categories indicating feeling rather not informed ('feeling little informed': 27.8% of males, 38.9% of females; 'feeling not informed at all': 9.5% of males, 18.7% of females) ('undecided': 0.2% of males, 0.7% of females; 'refused': 0.2% of males). As this marked the level of previous knowledge about drones as a potential confounding variable for the gender difference in noise concerns, we subsequently examined the existence of gender differences in noise concerns, separately for each of the four levels of drone knowledge. Whereas there were no significant gender differences in noise concerns for participants who rated themselves as either 'somewhat informed',  $\chi^2(1) = 3.79$ , Bonferroni-corrected  $p = .21$ , or 'not informed at all',  $\chi^2(1) = 2.18$ , Bonferroni-corrected  $p = .56$ , we found significant gender differences for respondents feeling either 'very well informed',  $\chi^2(1) = 9.94$ , Bonferroni-corrected  $p = .006$ , or 'little informed',  $\chi^2(1) = 8.36$ , Bonferroni-corrected  $p = .015$ . The two last mentioned effects indicated that females as compared to males more frequently reported to have noise concerns. Therefore, although gender differences in noise concerns at least partly disappeared when it was controlled for the level of knowledge about drones, this confounding variable could not fully account for differences between females and males in concerns about drone noise.

Finally, we examined the participants' interest in modern technology in general as a potential confounding variable for the gender difference in concerns about drone noise. Participants indicated their technical interest on an eleven-point Likert scale ranging from '0 – not interested at all' to '10 – very interested'. For data reduction, we calculated this scale's quartiles for the current sample and assigned each respondent to one of four quartile bins according to reported technical interest. Hence, the first bin represented technical interest values  $\leq 6$ , the second bin indicated value 7, the third bin represented value 8, and the fourth bin indicated values  $\geq 9$ . On this basis, we found that the distribution across technical interest bins significantly depended on gender,  $\chi^2(3) = 102.42$ ,  $p < .001$ . Whereas a large proportion of

females was represented in the two bins indicating relatively lower technical interest (bin '≤6': 46.1%, bin '7': 24.7%, bin '8': 18.5%, bin '≥9': 10.0%, undecided: 0.7%), a large proportion of males was represented in the two bins indicating relatively higher technical interest (bin '≤6': 21.1%, bin '7': 17.4%, bin '8': 28.8%, bin '≥9': 32.5%, refused: 0.2%). As this marked technical interest as a potential confounding variable for the gender difference in noise concerns, we subsequently tested the existence of gender differences in noise concerns, separately for each of the four technical interest bins. In this way, we found a significant gender difference in noise concerns for technical interest bin '≤6',  $\chi^2(1) = 12.65$ , Bonferroni-corrected  $p = .002$ , as well as bin '7',  $\chi^2(1) = 6.57$ , Bonferroni-corrected  $p = .042$ . These two effects indicated that females as compared to males more frequently reported to have noise concerns. In contrast, there was no significant difference in noise concerns between females and males for technical interest bin '8',  $\chi^2(1) = 5.62$ , Bonferroni-corrected  $p = .071$ , and bin '≥9',  $\chi^2(1) = 0.60$ , Bonferroni-corrected  $p = 1$ . Thus, technical interest could only in part account for the gender difference in concerns about drone noise.

### Data weighted for representativeness

As the results reported above refer to the original (i.e., raw) survey data, the 'results' section is completed by an additional report of data that were weighted to ensure representativeness for the German population with respect to a number of central sociodemographic factors (for more details, see 'methods' section). In this way, it is ensured that the current study's two main findings regarding general attitude and noise concerns on the superordinate group level were similar when using weighted survey data.

First, similar to the unweighted data reported above, the data weighted for representativeness showed that the majority of the male German population had a rather positive attitude towards civil drones (63% rather positive, 29% rather negative, 8% undecided). In contrast, there was no clear majority for any side in the female German population (44% rather positive, 47% rather negative, 10% undecided). Second, also similar to the reported unweighted data, the data weighted for representativeness indicated that noise concerns were more widespread among the female German population (62% rather concerned, 33% rather not concerned, 5% undecided) as compared to the male German population (41% rather concerned, 53% rather not concerned, 6% undecided).

## DISCUSSION

The present study was based on a telephone-survey in Germany. It extends Eißfeldt and colleagues' [4] report of the same dataset by providing inferential statistics for the notions that a rather positive general attitude towards civil drones was more widespread among male than female respondents and that females more frequently reported to have concerns about civil drones. This further corroborates prior research (e.g. [2, 6]). Importantly, this gender difference was revealed to be statistically significant for six out of the seven areas of concern that were assessed in the current study (e.g., including concerns about noise, damages and injuries, and the violation of privacy). Hence, our findings emphasize the ubiquity of gender differences in various indicators of drone acceptance.

Moreover, the present study contained a set of analyses of potential confounds of such gender differences using the example of noise concerns. Although we revealed substantial differences between female and male participants in the existence of drone experience, the

level of knowledge about drones, and the interest in modern technology in general, none of these three variables could fully account for the reported gender difference in noise concerns. For example, the finding that female as compared to male respondents more frequently reported to have noise concerns was shown to be statistically significant both for participants with and without prior drone experience. However, it has to be noted that there was no statistically significant gender difference in noise concerns for specific subgroups of respondents, for instance participants with very high technical interest. In this way, the present study yielded evidence that certain confounding variables might at least to some degree contribute to the existence of gender differences in noise concerns. Therefore, future research should further examine whether gender differences in drone acceptance could in part be driven by certain types of confounds which might frequently occur between females and males (see also e.g. [6]). For this purpose, it may be beneficial to assess potentially confounding variables in a more detailed way. For example, instead of asking whether participants have private and/or professional experience with civil drones or not, one could assess the estimated number of hours of prior experience with these vehicles.

Beyond the present study's detailed comparison of the prevalence of concerns about civil drones between female and male respondents, we also revealed gender differences in the importance of the seven assessed areas of concern for explaining the participants' general attitude towards civil drones. Although several prior studies showed noise concerns to be among the least widespread of all concerns about civil drones (e.g. [2-4, 11, 12]; but see [13]), the recent study of Eißfeldt and colleagues showed noise concerns to be the most important of all assessed concerns for explaining the participants' general attitude towards these vehicles [4]. By means of gender-specific CHAID models, the present study built onto this line of research and demonstrated that noise concerns best explained female respondents' attitudes towards civil drones. In contrast, concerns about damages and injuries were most important for explaining male participants' attitudes. Therefore, the current findings refine the previous study's conclusion.

One key question that arises when discussing the present results is whether the lower prevalence of a positive general attitude towards civil drones and the higher prevalence of concerns about these vehicles among females indeed reflect drone-specific judgements or, alternatively, are an expression of possible broader gender tendencies. Importantly, besides drone acceptance, gender differences in attitudes and concerns have previously been reported in several other contexts that have certain aspects in common with the current topic. For example, the mentioned representative online-survey of the German Unmanned Aviation Association (VUL) carried out in 2017 indicated fewer females to be supportive of autonomous vehicles than males, not only regarding aircrafts, but also with respect to rail and road traffic [2]. Similarly, prior research yielded evidence that females on average have less favorable attitudes towards technology use [15]. Moreover, in accordance with the current findings as well as previous studies in the field of drone applications (e.g. [6]), concerns about issues of privacy in other contexts such as using mobile devices have previously also been shown to be more common among females (e.g. [16]). Hence, instead of representing judgements that were specifically made with respect to the topic of civil drones, the present findings could alternatively be an indicator of rather broad gender tendencies that might also emerge in other domains. It will be important for future research to further examine the validity of these two alternative interpretations.

In any case, the fact that the present study substantiates the notion that a positive general attitude towards civil drones is less widespread among females, while drone concerns (e.g., about noise) are more widespread in this group should not be underestimated. It is known

from prior research that direct noise exposure variables can only explain about one third of the variance in noise annoyance. Other factors such as personal noise sensitivity as well as attitude towards the noise source have to be taken into account as well [10]. Therefore, a lower prevalence of a positive general attitude towards civil drones and a higher prevalence of (noise) concerns about these vehicles among females might indicate a higher risk of being annoyed by drones. Furthermore, annoyance is speculated to constitute one potential mechanism by which noise can impair people's health [10]. Hence, if annoyance by civil drones indeed was more widespread among females, this group would perhaps also be at higher risk of health impairments from drone traffic. Importantly, such aspects have to be considered in future studies.

## CONCLUSIONS

In sum, the current study not only substantiates the notion that females as compared to males are less positive and more concerned about civil drone applications, but also demonstrates noise concerns to be of particular importance for explaining females' general attitudes towards these vehicles, while concerns about damages and injuries were especially relevant for explaining males' general attitudes on this topic. Although future research is needed to further investigate the influence of potentially confounding variables and to examine the level of drone-specificity of the present findings, the reported gender differences were shown to have a substantial impact in the context of drone acceptance. Thus, the current results ought to be considered when developing civil drone applications.

## Acknowledgements

The authors thank infas (Institute for Applied Social Sciences, Bonn, Germany) for implementing the telephone-survey. Moreover, they are grateful to Maria Stolz, Anne Papenfuß, Marcus Biella, and Dirk Kügler (DLR German Aerospace Center, Institute of Flight Guidance, Braunschweig, Germany) as well as Janina Belz (infas) for their conceptual and intellectual contributions.

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