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OF PEOPLE AND DRONES

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ABSTRACT

In recent years civil drones have become more and more visible in everydays life. Reports in the media are numerous, they cover a variety of aspects and technical developments, and everybody is used to bird-eye views being a common feature in television, movies and photography. However little is known how the public perceives this development. This paper reports the results of a representative national study on the acceptance of civilian drones. In the presentation of the results, this article describes the social acceptance of civilian drones and thus helps to better understand the perception of civil unmanned aerial vehicles.

KEYWORDS

Aviation; drones; unmannd aerial vehicles (UAV); acceptance; telephone survey.

INTRODUCTION

Drones - understood here as unmanned aerial vehicles (UAV) of a civilian nature - are becoming increasingly visible in public perception. Applications are ranging from parcel delivery to animal welfare, from the production of live images of major events to the fight against crime, and from the inspection of industrial facilities to the design of artificial fireworks. Almost monthly, the media report on new applications and patent applications. Drones help with the construction of ropeways and high bridges, inspect wind turbines, investigate whales on the high seas, and amongst others warn of sharks on the beach. Many drone applications such as precision farming are considered to have high potential for saving resources, and drone technology often is regarded as having disruptive quality for certain markets and industries. On a global level the International Transport Forum (2018) of the OECD has described chances and challenges of future drone usages in a recent report. National and international institutions are trying to keep up with the rules and procedures to be established with dynamic development. The European Commission plans to launch the “U-space” as an overarching system for unmanned aerial transport by 2019, ensuring safe and environmentally sound drone operations in the lower airspace. Furthermore EU-wide rules for safety of drones have recently been published as regulation (EU) 2018/1139 of the European Parliament and of the Council of 4th 2018. With the continued strong increase in the use of drones expected by all involved, there is also an increasing interest in the public's perception of this new element. As airport planning has repeatedly shown, a lack of public acceptance can be a limiting factor for further growth in aviation (e.g. Suau-Sanchez, 2011). Similarly, certain concerns among the population regarding the use of drones could restrict their wider dissemination. Likewise, existing positive expectations for the use of drones may promote the expansion of drones.

In February 2017 a dedicated Unmanned Aerial Systems (UAS) workshop was held at the DLR German Aerospace Center, Institute of Flight Guidance in Braunschweig. For the first time all DLR units who are involved in UAS research projects - six institutes and eight on-going projects - worked on the DLR strategy on the UAS airspace integration. Better knowledge about the acceptance of drones in the German population was identified as important factor for further proliferation of drones in daily life.

METHOD

The study was conceptualized in a joint effort of two departments of DLR, flight guidance human factors (FL-SEG) in Braunschweig and aviation and space psychology (ME-PSY) in Hamburg and a prototype fielded February/March 2018 by infas Institute for Applied Social Sciences as Computer Assisted Telephone Interview (CATI). Using a dual frame technique with 70 % landline and 30 % mobile phones a random digital dial design was used with the aim of reaching conclusive results representative for the German population.

The questions were asked by specially trained employees in a telephone interview of about 20 minutes duration in a standardized manner. The answers were coded after appropriate template directly online. For quality assurance online supervision could be performed occasionally by listening in of senior staff. The study fully adhered to the professional code of conduct for telephone interviews agreed on in Germany (ADM 2016).

Sample description

832 respondents took part in the study, which was conducted between March and May 2018, and answered all questions. Respondents were 51.8% male, 48.2% female, age ranged from 14 - 94 years (mean 51.5, Standard deviation SD 18.2), size of household (mean 2.5, SD 1.3). The response rate was calculated at 3.8 % following statistical procedures published by the American Association for Public Opinion Research (AAPOR 2016) meaning about every 25th eligible phone number led to a full interview. Following the same procedures the cooperation rate for the study was calculated with 9.4% (defined as percentage of interviews completed divided by sum of interviews completed (832) plus sum of partial interviews (5) plus sum of refusals (6.952) and sum of other nonresponses (1.048)).

Weighting

Educational background and income of the sample was somewhat higher compared to the German population, also the gender distribution according to census information should be exactly opposite. In order to compensate bias in the sample design, infas provided survey weights, which consisted of a probability weight and a calibration. The probability weight itself is composed of a dual frame weight, which basically integrates the two separate samples from two sample frames in one sample. Therefore it adjusts the proportion of landline and mobile phone numbers. Additionally, the probability weight controls the different sampling probabilities of persons using their different numbers of mobile phone numbers on the one hand, and the household size and the different number of landline phone numbers on the other hand.

Furthermore, the calibration of the survey data refers to recent census data available for Germany concerning age and gender, educational background, size of household, employment state, region and size of community. In consequence the data were adjusted to provide results generizable for the German population as whole. In this paper weighted results will be referred to when presenting descriptive data. Raw data will be referred to for results of explorative analysis.

RESULTS

Associations with the term drone

After explaining the purpose of the study and gaining consent to participation, at the beginning of the interview subjects were asked whether they knew the term 'drones' in aviation. All the 95% participants answering with: 'Yes' have been asked subsequently in an open question to to mention spontaneously what they associate with a drone: Was verbinden Sie mit einer Drohne?

A total of 794 participants gave answers reaching from one single word to several complex sentences, all being transcribed onsite by the interviewer. Participants mentioned between 1 and 9 different aspects with a majority mentioning 2 aspects (Mean 2.44, SD 1.26). A total of 7 subjects answered just 'nothing'. The most mentioned single aspect was 'parcel delivery', followed by surveillance/monitoring, toy, military, dangerous and taking pictures.

Table1 *Associations with the term drone*

Associations reported	Frequency sorted	Rank
parcel delivery, transport, air taxi	182	1
military, war, weapon	167	2
recording, camera, view from above	162	3
taking pictures, photos, video, film	148	4
surveillance, monitoring, observation	142	5
toy, fun	118	6
espionage, exploration	102	7
dangerous	89	8
remotely controlled, flying object, unmanned	89	9
endangering air traffic	70	10
privacy, neighbors, big brother	66	11
leisure time, hobby	62	12
regulatory needs, license	55	13
new technology	48	14
*ambivalent	46	15
**other	29	16
negative	25	17
police, security	23	18
possible misuse	21	19
threatening	20	20
accidents	19	21
nonsense	14	22
lifesaving	13	23
useful	13	24
embarrassing	12	25
science	11	26
construction	8	27
traffic supervision	8	28
noise	8	29

* ambivalent was coded in addition when positive and negative associations were provided in context

**other was coded when association was singular and not connected to 'drone',e.g. 'ufo' or 'artificial intelligence'

Later these qualitative data have been coded into categories. According to the level of detail the numbers of categories vary from about 60 rather narrow categories down to 6 very complex categories. Table 1 shows a

solution with 29 categories that was reached by exluding all associations with less than 1% frequency and resulted in coverage of 90% of all associations.

To provide a further view of the diversity of associations figure 1 provides a word cloud of associations reported, showing the top 98 words with highest frequency out of 715 possible words in alphabetical order. The size and colour saturation represents the frequency.

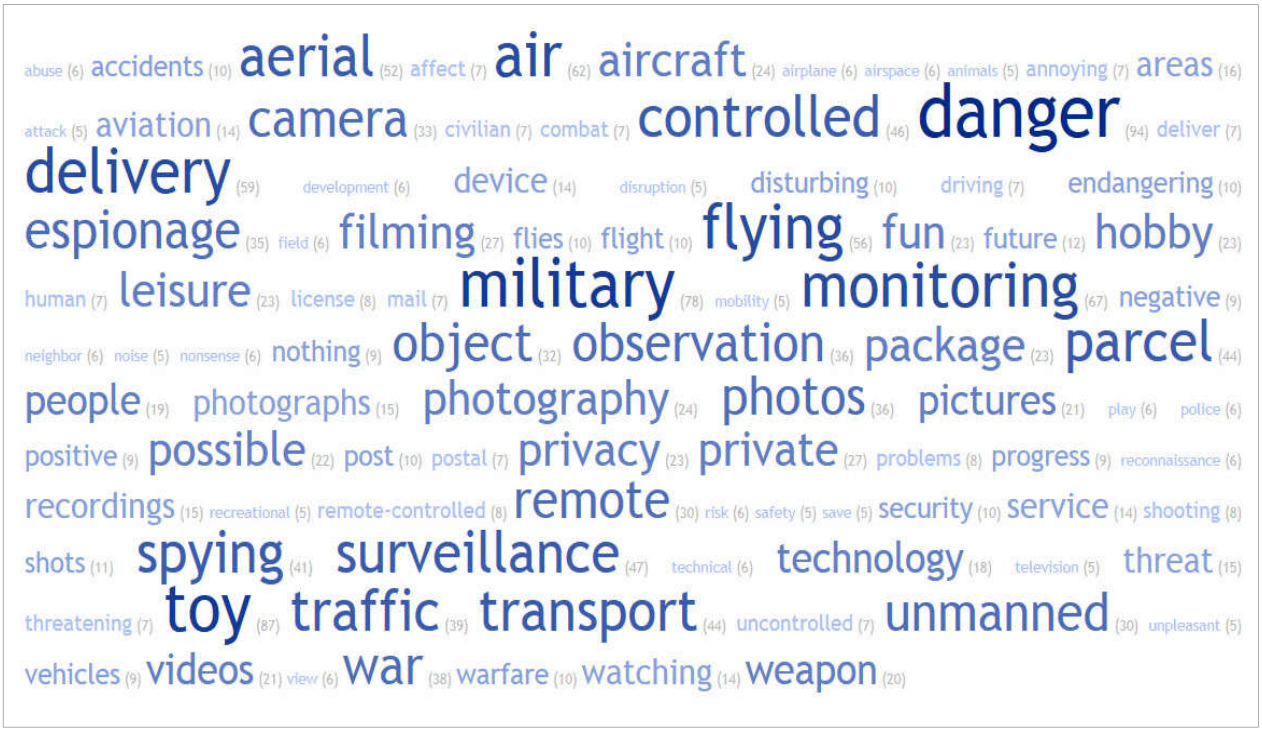

FIG. 1. Associations with the term drone. Word cloud based on frequency

Acceptance of civil drones in Germany

After being asked for their associations with the term drone study participants were instructed that the drones asked for in the remainder of interview were unmanned aircraft looking like small helicopters with several rotors, typically four or more, and that only civil applications were relevant for this study. They then were asked how they would describe their general attitude towards civil drones, whether it was rather positive or rather negative? In case they could not decide the answer was coded as 'undecided'.

As reported above, statistical methods have been applied to adjust raw data for representativity. In the case of the general attitude towards civil drones its variation with age and gender will be shown in the adjusted way representative for the German population (Figure 2). The adjustment has been made to reflect age and gender, educational background, size of household, employment state, region and size of community of the German population.

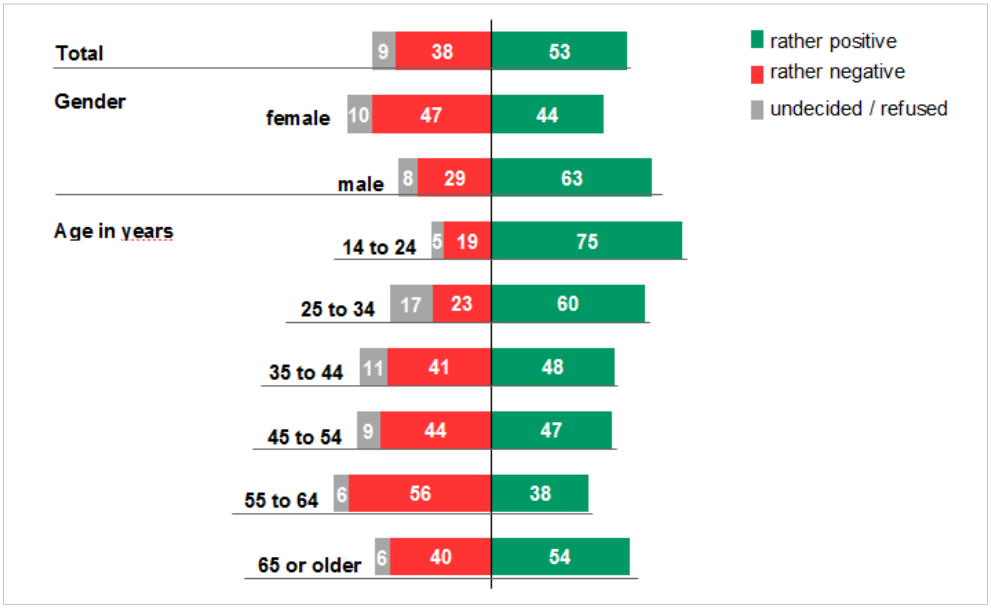

FIG. 2. Attitude towards civil drones. Values in percent; adjusted for representativity

Showing a somewhat split distribution of negative and positive responses to civil drones there is a clear advantage for the positive side (53% rather positive, 38% rather negative and about 9% undecided).The results vary with sociodemographic factors like gender and age: Male respondents are more positive toward civil drones compared to females,younger study participants show higher acceptance than older ages. Interestingly for senior citizens aged 65 or above the acceptance reaches a level similar to the total sample again.

Areas of concern with civil drones

Study participants have been asked how far they were concerned or unconcerned about certain aspects of civil drone usage. In randomized sequence the seven aspects in question were: transport safety, animal welfare, crime and misuse, noise, violation of privacy, liability and insurance, and damages and injuries, multiple answers were possible. Most of the respondents were concerned about the possibility of abusive use of drones for criminal purposes (89%), followed by concerns about violation of privacy (86%). The next three aspects were connected to potential mishaps and showed nearly similar amount of concerns: Concerns about matters of liability and insurance (76%), about damages and injuries by drones falling down (75%) and concerns about drones endangering transport safety (74%). Slightly less respondents (71%) indicated concerns about animal welfare. Concerns about noise were mentioned by 52%, indicating about every second respondent was concerned about the noise generated by drones. As a whole, a large majority of participants named at least three or more aspects of concern about civil drone usage (91%). The number of concerns mentioned varied with age and gender, being women and older respondents more concerned than younger or male respondents.

Experience and concerns

Less than half of the participants (39%) report having some experiences with drones in private (31%), job (3%) or both (5%) contexts. Looking into the concerns expressed by this group reveals that concerns about accidents, about animal and traffic risks are significantly less for those having some kind of experience with drone compared to those having no experiences. CHI square tests at the 10%-level reveal significant values for concerns about damages and injuries χ^2 (1) = 3.09, p = .08, OR = .76; animal welfare χ^2 (1) = 4.29, p = .04, OR = .73 and transport safety χ^2 (1) = 3.39, p = .07, OR = .75.

Out of those having reported some experience with drones the majority has seen a drone (77%), heard a drone (51%) or been present when others flew a drone (50%). Only 28% report having flown a drone themselves, meaning that out of the total sample roughly 11% have some experience flying a drone.

However, when looking into information about whether a respondent has or has not reported having heard a drone yet, a higher percentage of noise concerns was revealed: χ^2 (1) = 3.29, p = .07, OR = 1.45 for those having heard a drone.

Knowledge about drones and concerns

Towards the end of the interview respondents have been asked how far they felt informed about drones in general. Answers were given on a 4-point-Likert-scale ranging from 1 = very well informed to 4 = not informed at all. This subjective level of information has been shown to be positively correlated with the general attitude toward civil drones, the higher the subjective knowledge, the higher the acceptance and vice versa (see Eißfeldt et al. 2018). In the following the focus is on whether being concerned about drones or not is related to the subjective level of information or – in short – knowledge about drones. For comparing the two groups the t-Test was used.

Table 2
Different drone-related concerns and knowledge about drones, t-test

aspect of concern	group (1 = rather concerned, 2 = rather not concerned)	M	SD	T	p	effect size
noise	1	2.59	0.88	3.56	> .001	0.25
	2	2.37	0.86			
transport safety	1	2.52	0.88	1.05	.294	-
	2	2.44	0.86			
animal welfare	1	2.58	0.86	3.96	> .001	0.30
	2	2.32	0.88			
liability and insurance	1	2.55	0.87	3.55	> .001	0.29
	2	2.29	0.88			
crime and misuse	1	2.53	0.86	3.14	.002	0.39
	2	2.19	0.92			
violation of privacy	1	2.53	0.87	2.34	.019	0.24
	2	2.32	0.85			
damages and injuries	1	2.57	0.88	4.03	> .001	0.31
	2	2.30	0.84			

Results reveal significant group differences for concerns on noise (t(799) = 3.56, p < .001), animal welfare (t(819) = 3.96, p < .001), liability and insurance (t(812) = 3.56, p < .001), crime and misuse (t(820) = 3.14, p = .002), violation of privacy (t(821) = 2.34, p < .019) and damages and injuries (t(822) = 4.03, p < .001). In each case respondents who are less informed about drones feel more concerned about these issues than those who are not concerned. Only in terms of drones being a potential threat to transport safety no significant group differences were found (t(810) = 1.05, p < .294).

Acceptance of varying purposes of drone usage

During the interview the respondents have been asked how far they in general would accept various applications of drones, resulting in different levels of agreement. Answers were given on a 4-point-Likert-scale ranging from 1 = totally agree to 4 = totally disagree. The different purposes were asked for in

randomized order to avoid sequence effects. Agreement was highest for official uses as catastrophe response and life-saving efforts, but also for police and security activities. It was low for leisuretime activities, and surprisingly low for transport and parcel delivery. Table 3 shows the results in ranked order.

Table 3
Agreement towards different applications of civil drones, highest agreement on top

Purposes of drone usage	Average agreement (max = 1, min = 4)	Standard Deviation (SD)
Catastrophe response	1.43	.70
Rescue operations, lifesaving efforts, civil defense	1.56	.83
Research purposes	1.59	.74
Monitoring of infrastructure (transport or energy)	1.82	.90
Medicine (transport)	1.83	.98
Agriculture	2.07	1.02
Photo and video recordings for news	2.40	.99
Leisure time activities	2.62	.98
Parcel delivery	2.73	1.02
Photo and video recordings for advertising	3.09	.99

In a further question the respondents have been asked for what purposes they would agree to use a drone themselves: For leisure time activities, for first aid, parcel delivery, police and fire service or as unmanned taxi. Question were asked in randomized sequence and answered using the same 1-4 scale mentioned above. To analyze whether this willingness is affected by the general attitude toward drones mean values were compared between three groups: participants with attitude toward drones being rather positive, not sure, or rather negative. For this purpose a univariate ANOVA was conducted.

As table 4 indicates for every type of use results reveal significant differences between the groups. When using drones for first aid, participants with a positive attitude (M = 1.59, SD = 0.82) are more likely to make use of it than those with a negative attitude (M = 2.21, SD = 1.10), (F(2, 814) = 38.71, p < .001, η^2 = .08). Furthermore respondents who were not sure about their attitude towards drones were more willing to use them in terms of first aid than persons with a negative view. No significant between participants with a positive attitude and those who are undetermined were found.

With regard to the usage for leisure time activities the statistics show that people thinking positive (M = 2.74, SD = 1.07) about drones are more willing to use them for leisure time activities than people having negative (M = 3.50, SD = 0.78) or undetermined positions (M = 3.25, SD = 0.90), (F(2, 825) = 61.59, p < .001, η^2 = .13). Similar results are found for using drones as unmanned taxis. Also in this case participants with a positive attitude (M = 3.08, SD = 0.91) towards drones are more likely to use them as taxi than those with a negative (M = 3.69, SD = 0.60) or undetermined one (M = 3.42, SD = 0.86), *(*F(2, 814) = 56.08, p < .001, η^2 = .12).

In terms of parcel delivery there are significant differences between study participants with positive (M = 2.65, SD = 1.04) and negative attitude (M = 3.44, SD = 0.87) and between those thinking negatively about drones and people who are not sure (M = 3.21, SD = 1.02), *(*F(2, 824) = 64.20, p < .001, η^2 = .13). Findings for drones in police and fire service are similar. Results also reveal significant differences between persons with positive (M = 1.54, SD = 0.73) and negative positions (M = 2.02, SD = 1.02) as well as between participants with negative and neutral view (M = 1.52, SD = 0.75), *(*F(2, 816) = 31.17, p < .001, η^2 = .07).

Table 4
Drone acceptance and respondents willingness to use drones for different purposes

	group 1	M	SD	group 2	M	SD	F	p	effect size
first aid services	*between groups*	-	-		-	-	38.71	< .001	0.08
	rather positive	1.59	0.82	rather negative	2.21	1.10	-	< .001	0.64
	rather positive	1.59	0.82	not sure	1.76	0.97	-	.354	-
	rather negative	2.21	1.10	not sure	1.76	0.97	-	.003	0.42
leisure time	*between groups*	-	-		-	-	61.59	< .001	0.13
	rather positive	2.74	1.07	rather negative	3.50	0.78	-	< .001	0.81
	rather positive	2.74	1.07	not sure	3.25	0.90	-	< .001	0.49
	rather negative	3.50	0.78	not sure	3.25	0.90	-	.091	-
parcel delivery	*between groups*	-	-		-	-	64.20	< .001	0.13
	rather positive	2.65	1.04	rather negative	3.44	0.87	-	< .001	0.82
	rather positive	2.65	1.04	not sure	3.21	1.02	-	< .001	0.54
	rather negative	3.44	0.87	not sure	3.21	1.02	-	.188	-
police and fire service	*between groups*	-	-		-	-	31.17	<.001	0.07
	rather positive	1.54	0.73	rather negative	2.02	1.03	-	< .001	0.55
	rather positive	1.54	0.73	not sure	1.52	0.75	-	.983	-
	rather negative	2.02	1.02	not sure	1.52	0.75	-	< .001	0.51
Air taxi	*between groups*	-	-		-	-	56.08	< .001	0.12
	rather positive	3.08	0.91	rather negative	3.69	0.60	-	< .001	0.78
	rather positive	3.08	0.91	not sure	3.42	0.86	-	.013	0.38
	rather negative	3.69	0.60	not sure	3.42	0.86	-	.044	0.42

Note. Small mean values imply that people would like to use drones for that purpose whereas large ones mean they would not. For between group comparisons Eta² is given as effect size, for pairwise comparisons Cohen's d.

Results reveal that in every case respondents with a positive attitude towards drones are more willing to use them for different purposes compared to respondents with rather negative attitudes. Also respondents who are undetermined about drones often are more likely to make use of them than persons thinking in a negative way about civil drones. Mean values overall indicate that the use of drones for first aid (M = 1.87, SD = 1.01) and police and fire service (M = 1.74, SD = 0.90) is most agreed to whereas the use as unmanned taxi is rated as least favorable (M = 3.37, SD = 0.84).

Overflight acceptance

Concerning the new regulations in Germany effective since October 2017, similar to flying over groups of people, industrial facilities or public institutions, any overflight of peoples homes is prohibited as long as the owner has not indicated prior concent (BMVI 2017). The current study shows this overflight ban to be placed well: The participants were concerned about drones flying over their own homes, especially at night. However for previously accepted purposes of drone usage (see Table 3), mainly official functions of rescue and protection, drone overflight was rather agreed with.

Table 5
Overflight acceptance for different conditions

Overflight Acceptance	average agreement	Standard Deviation
for accepted purposes	2.2	0.9
during the day	2.8	1.0
at night	3.1	0.9

Agreement: 1 =totally agree, 4 = totally disagree, undecided/refused/ very different excluded

When asking for overflights at daytime in general, results showed less acceptance (M = 2.8; SD = 1.0) compared to asking for flight reasons accepted before (M = 2.2; SD = 0.9). Overflight at night was accepted least, with an average agreement of 3.1 reflecting clear disagreement.

Effect of interview - slightly positive trend of acceptance

For many participants of this survey the interview will have been the first time of talking about drones for about 20 minutes in detail. Touching a variety of positive and negative aspects the general aim of conduct was neither to scare nor to overly convince respondents of drone usage. To control potential effects a follow up question was placed at the end asking for a potential change of opinion towards drones due to the interview content.

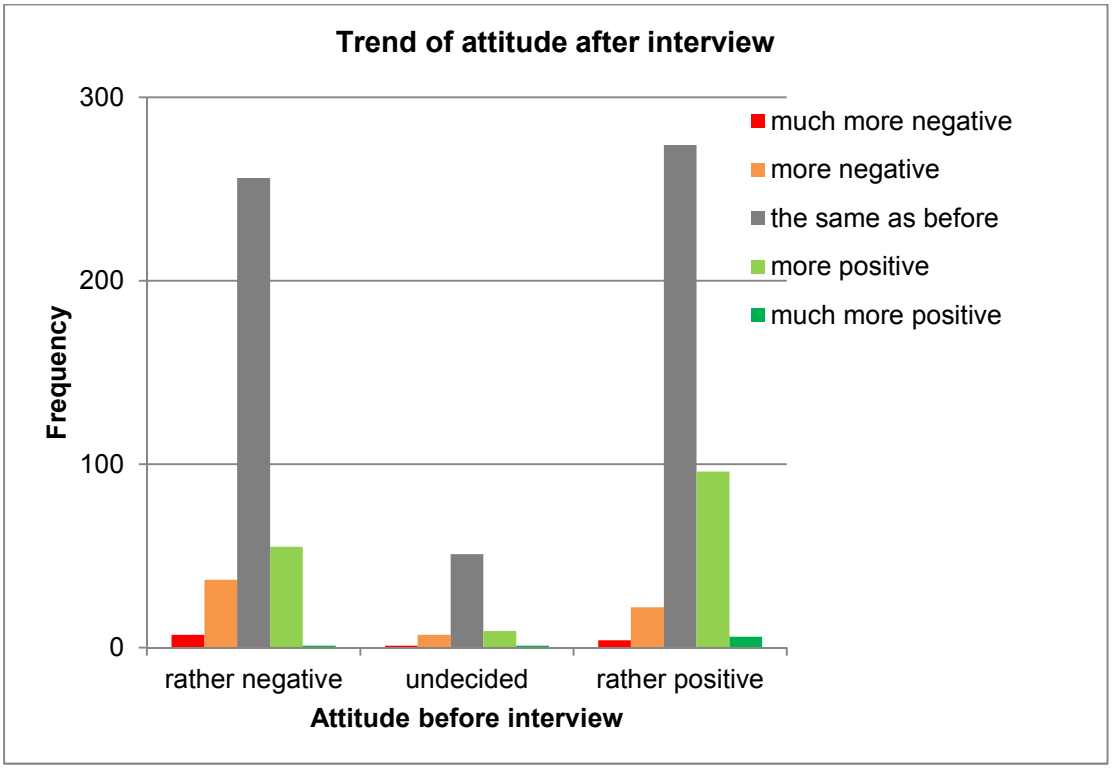

FIG. 3. Trend of attitude towards civil drones after interview

Evaluation revealed a majority (70%) of stable opinions at the end of the interview and a slightly higher percentage of subjects with an opinion becoming more positive (20%) than a more negative (10%). This was the same regardless what has been the initial statement of acceptance, rather negative, rather positive opinion or undecided concerning the civil usage of drones. If seen as a treatment, the interview conducted had somewhat a positive effect on all levels of acceptance.

DISCUSSION

The results of the study provide an overview of the acceptance of civil drones in the German population. The term “drone” is well known to the population and associations are manifold. The impression however is that the necessary distinction between military and civil use of drones can be and is being made by many of the respondents.

Referring to weighted results 53% of German citizens are indicating a rather positive attitude toward drones, being 15% more than those being rather negative about civil drones, the rest being undecided. This is a clear improvement compared to the evenly split (42% : 42%) reported from a recent national survey (VUL 2017). The increased acceptance might be due to the the CATI method used here which could be more interactive than filling in an online survey, however it could also be an effect of recent national and international legislation. A more detailed look revealed that the attitude towards drones in civil usage context has a complex pattern of origins. Amongst other things, it depends on gender, age, housing situation, but also on existing interest in technical matters and the individual level of information about civil drones. Civil drones have various possible applications: They can be used for leisure time activities and parcel delivery, but also for life-saving efforts, catastrophe response or police and security activities. Interestingly the willingness to use a drone in person is lowest for those usages having the highest economic interest behind (parcel delivery) and the highest reflection in the news (air taxi). The two reasons finding highest acceptance are rescue and public safety, applications which at least the urban population is already used to overflight at present by helicopters. As analysis has shown respondents with a positive attitude towards drones are more willing to use them for different purposes than those being more negative. Also respondents who are undetermined often are more likely to make use of drones than persons thinking in a negative way about that issue. This aspect could indicate that those currently undecided about drone acceptance will over time rather change to a positive attitude than to the opposite, as concerning own usage at least the barrier from undecided to negative attitude seems stronger.

Technical interest in general and knowledge about drones play an important supportive role for acceptance. This finding is in line with prior research: The better citizens are informed about possible chances and risks the more they accept the use of drones (Mac-Sweene George, (2003), Clothier (2015)). Most likely this aspect is also being reflected by the positive trend found with this telephone interview: Providing information on drones led to more positive than negative changes of attitude. However this trend also shows that the issue of drones is still young and attitudes can still be influenced and to some degree changed to any direction. According to models of technology acceptance (eg Davis, Bagozzi and Warshaw (1989)) the attitude toward using a technology is dependent on the perceived usefulness (subjective perception that the application of the technology improves the performance) and the perceived ease of use (the perception of the necessary effort to learn how to use the application/ technology. Both aspects could be enhanced through increased knowledge and experience. The results presented have shown that having own experience with drones can significantly reduce subjective concerns and increase overall acceptance. Providing regulations is one way to shape experiences positively, for instance by issuing an overflight ban. However, as recent research has indicated, there are more aspects requiring attention as potential influences on drone acceptance in the society including design, noise, and movement patterns (Chang et al. 2017).

It is likely that the public is still forming its opinion about civil drones. One way to lead this process positively and further increase the overall acceptance of civil drones could therefore be the encouragement of information campaigns tailored to specific target groups identified in this study. Further research should focus on the future development of the public’s acceptance of civil drones, to foster a successful development of the U-space and its applications in Germany.

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