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SUPPORTING CITIZENS' POLITICAL DECISION-MAKING USING INFORMATION VISUALISATION

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Research paper

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Abstract

Individual decision-making is a complex process. If carried out by individual citizens in the context of politically relevant decisions, serious consequences at all levels of a society might occur. That is why these decisions need to be made with care and preferably on a broad set of information to reflect citizens' true preferences. However, due to limited attention, citizens often consider only salient aspects in their decision-making. To mitigate unwanted consequences following therefrom, citizens are in dire need of decision-support. We address this need by developing an Information Systems (IS) tool. Being based on information visualisation, our tool supports citizens by providing instant feedback. To ensure a meaningful engagement, the IS tool is designed according to gamification principles. A first instantiation in the context of renewable energy acceptance in Germany yields three key findings: First, we find indications that young, urban, and environmentally aware citizens are willing to accept a high percentage of renewable wind energy. Second, we find that the tool influences citizens' decision-making. Third, we find citizens to update, however not completely turn over their preferred level of renewable wind energy after interaction with the tool. This holds true across different cross-sections of the population.

Keywords: Decision-Making, Decision-Support, Citizens, Information Visualisation, Live-Feedback, Renewable Energy, Wind Turbine Acceptance, Gamification.

1 Introduction

Technological innovations are proliferating and with them our opportunities to collect, communicate and compute information (van Knippenberg et al., 2015; George et al., 2014; Hilbert and López, 2011). Hence, in situations of decision-making, more information is available to decide upon. However, the flipside of this enriched information base is a phenomenon called "information overload" highlighting that individuals' attention in decision-making has not seen corresponding shifts (Knippenberg 2015). According to behavioural theories, individuals are endowed with bounded rationality. Having only limited cognitive capabilities, individuals use simplification processes at the expense of complete information (Gigerenzer and Todd, 2001; Goldstein and Gigerenzer, 2002).

One fundamental manifestation of such a simplification process is described by the salience theory as proposed by Bordalo et al. (2012, 2013). The phenomenon of salience occurs if one or a few aspects in a decision situation draw an individual's limited attention more than other aspects. Hence, salient aspects are dominating decisions (Bettman et al., 1998; Slovic, 1995). The distortion leads to decision outcomes that fail to represent true preferences.

Being able to decide in line with one's preferences is the essence of intelligent behaviour (Warren et al., 2011; Slovic, 1995). In situations when one cannot form preferences due to e.g., information overloads, the implications might affect all levels of society – especially in the context of politically relevant decisions. A concrete example thereof is the withdrawal of the United Kingdom from the European Union (EU). Focusing on the salient aspect of leaving such as saving payments to the EU, which were estimated around £350m a week, British people might not have primarily focused on all aspects and implications such as trade, customs, or border implications for Northern Ireland. However, neither at the time of the vote, nor during the recent years afterwards, a clear understanding of how and when to withdraw from the EU existed. The implications thereof were serious: Parliament has rejected the negotiated plan to leave several times and the exit date has been postponed as well (Becker et al., 2017; Hobolt, 2016; Mueller, 2019).

Considering the serious consequences of information scaling faster than attention, fellow researchers have searched for a way to support individuals' processing of information in decision situations. In this context, particular attention has been brought to IS tools providing information visualisation functionalities. These range from common bar graphs to more sophisticated visualisations such as complete virtual environments (Lurie and Mason, 2007). Although a large variety of information visualisation tools are increasingly available to individuals in organizational and in consumer contexts (Lurie and Mason, 2007), little is known of such tools in the citizen context. Aiming to contribute to an inclusive world, within responsive, participatory, and representative decision-making at all levels, we formulate the following research question: *Does an IS tool influence individuals' decision-making in a citizen context?*

In response to this question, we develop an IS tool (please refer to Appendix A to access a documentation of the tool). The tool is considered IS-based, since it utilizes web-based information visualisation techniques to make the interaction with the tool more engaging. Thereby, we design the tool according to the gamification principles proposed by Liu et al. (2017). Gamification is an umbrella term referring to the utilization of elements from game design in a non-game application context with the aim of improving user engagement (Deterding et al., 2011). Thereby, gamification per definition can include many different elements i.a., also traditional interaction techniques such as filtering and zooming (Deterding et al., 2011; Figueiras, 2015).

Once built, we evaluate the performance of the gamified IS tool in the non-game application context of renewable energy i.e., onshore windfarm acceptance in Germany. We chose the context of renewable energy because it constitutes a major challenge of today's world (United Nations, 2019). Renewable energy is also considered as one of the 17 United Nations (UN) Sustainable Development Goals (SDGs). Within the context of renewable energy, we decided to focus on Germany, which has installed more wind turbines than any other European country (Wind Europe, 2019; NS Energy, 2019; Fleming, 2019).

In this applied context of German wind energy, there are of course many variables to consider. Given a plethora of interesting variables, including all of them simultaneously is challenging within one research project and with the aim of answering a clear-cut research question. Therefore, we make a deliberate decision to narrow the research focus to specific aspects for the sake of a clean research design and clear research question. More precisely, we focus on the variable land use by wind power, which is a current topic in Germany's wind context. Particularly, the German government is discussing new rules regulating the minimum distance for wind power from dwellings. The rule aims to keep new onshore wind turbines at least 1,000 meters away from residential areas. If released, the rules would have enormous implications on the availability of land areas for wind turbines (Bauchmüller, 2019; Witch, 2019). In this work, we develop an IS tool that visualizes the consequences (number and proximity of wind turbines) of the renewable energy portfolio selected by the users in an online survey. With this research, we contribute to an improved individual decision-making at the citizen level, which we believe is the first step towards enabling a participatory and representative decision-making at all levels of a society.

2 Theoretical Background

2.1 Preference Construction and Salience

In decision literature, normative and behavioural theories describe how decisions are made: Normative theories provide prescriptions of how individuals should optimally make decisions, focusing on the idea of a rational homo oeconomicus maximizing utility by processing the complete information related to a decision situation (Pareto, 1906). Conversely, behavioural theories document how decisions are actually made: specifically, Simon (1956) argues that decision-makers are frequently found to make sub-optimal and irrational decisions, a phenomenon resulting from limited cognitive resources to process information. More specifically, this phenomenon often results from a bounded working memory and bounded computational capabilities to anticipate decision consequences (Bettman et al., 1998; Simon, 1956; Slovic, 1995). This notion of bounded rationality affects decision-making and in particular the decisions' underlying preferences (Slovic, 1995).

The aspects of information considered in preference construction can be explained by the psychological theory of *salience* (Bordalo et al., 2012, 2013). Salience captures that individuals' attention is differentially directed to one portion on the environment rather than to others. The information contained in that portion then receives disproportionate weighing in human cognition (Bordalo et al., 2012, 2015; Taylor and Thompson, 1982). Transferred to decision situations, salience suggests that the valuation of a choice option occurs not in isolation, but in a comparative context (Bordalo et al., 2015). Decision makers, as salient thinkers, contrast the features of the option in question to the features of alternatives or of "normal" situations that come to the decision makers' mind. For instance, the valuation of a premium good may fall if the good's high price (instead of the good's quality) is salient, as when the good is presented together with cheaper alternatives or when the decision maker is accustomed to buying the same good at lower prices (Bordalo et al., 2015; Thaler, 1989, 1999; Bordalo et al., 2013; Tiefenbeck et al., 2016).

Considering individuals' variant preference structures and the role of salient information in decision-making, decisions do not refer to a solid, knowledgeable choice (Slovic, 1995). Thus, we argue that in the context of complex policy decisions, citizens need adequate decision-support to (1) base their decisions on a broad set of information, which (2) they are able to process. IS-based tools with information visualization (Card, 2009) may provide the means to fulfil both aspects and thus, to adequately support citizens in the construction of their preferences and in their decision-making.

2.2 Information Visualization for Decision-Support

As stated above, individuals' cognitive resources to process information are limited. As individuals acquire more information through vision than through all other senses combined, information visualisation (InfoVis) aids cognition (Heer et al., 2005; Dörk et al., 2013; Card, 2009). InfoVis refers to an IS-based, interactive visual representation of complex issues (Card, 2009; Yi et al., 2007; Hullman et al., 2011). Thereby, interactivity is key and aims at successively showing the data in manageable portions to reduce complexity. Doing so facilitates the user in information processing and uncovering insights (Figueiras, 2015; Hullman et al., 2011; Gelman and Unwin, 2013).

To enable interaction in InfoVis, different interactive techniques enable investigating the data (Figueiras, 2015; Ahmed and Mueller, 2014). A well-known interaction technique is *gamification*, which comprises several elements, including traditional interaction techniques such as filtering or zooming of data (Figueiras, 2015). Gamification is defined as "using game design elements in non-gaming contexts" (Deterding et al., 2011, p. 1). This results in goal advancements e.g., supporting healthier lifestyles, greener consumption, or improved financial decision-making (Koivisto and Hamari, 2014). More broadly, the aim of gamification is fostering user motivation and engagement, which in turn increases user activity in a particular context (Hamari et al., 2014; Kwak et al., 2019). As increased user activity is promising in corporate and consumer contexts, respective gamified InfoVis approaches have gained significant attention among practitioners over the last couple of years and led to a panoply of respective tools in both contexts (Huotari and Hamari, 2012; Hamari et al., 2014; Osatuyi et al., 2018). Even though gamified approaches are prominent in corporate and consumer contexts, little is known about such tools in the citizen context. Two related tools refer to "Crime-Mapping" (crimemapping.com) visualizing urban crimes in respective cities on an interactive map, and the "Wahl-O-Mat" by the German Federal Agency for Civic Education (wahl-o-mat.de/europawahl2019), pairing voters with political parties. However, these two examples either primarily inform rather than provide decision-support, or do not fulfil gamification standards (Liu et al., 2017). Thus, the examples do not address the pitfalls highlighted by preference construction and salience theory described above. Considering this, and responding to the call to arms of Dörk et al. (2013) to use InfoVis to engage citizens around social issues to support civic engagement, we develop a gamified InfoVis tool (henceforth IS-tool) and apply it to a novel context that is currently widely debated in society: environmental sustainability, and in particular, renewable energies.

2.3 Application Context: Citizens' Acceptance of Renewable Energy

Sustainability in general and replacing fossil fuels with renewable sources of energy in particular constitute a major challenge of today's world (United Nations, 2019). As such, renewable energy is considered in the SDGs, which were adopted by respective united member states in 2015 with the aim of achieving a sustainable development until 2030 (Sachs et al., 2019). The implication is clear: lacking sustainability is a rampant threat, which must be addressed with haste (Malhotra et al., 2013; Walsham, 2017). With the threat of climate change, sustainability has come to citizens' forefront. Public support for sustainability runs high in all European countries, as the FridaysForFuture-movement strikes for climate (FridaysForFuture, 2019) or the increased number of votes for the Green party in the 2019 European elections (Der Bundeswahlleiter, 2019b) exemplarily indicate.

As real world events and research reveal, it is one of the most common mistakes to take citizen support for granted and to expect people to welcome developments they claim to support (e.g., Wolsink, 2000, 2007; Wolsink and Devilee, 2009; Hoen et al., 2019). One concrete example refers to the trade-off between individuals' support for e-mobility and the resistance towards resulting consequences. In the case of Tesla, the construction of their Berlin factory was temporarily halted by demonstrations against the felling of trees, although Tesla's non-fuel powered cars are popular (Reuters in Berlin, 2020; Marquart, 2019). Further, in the context of renewable energy such as wind energy, researchers consistently highlight the dynamic in citizens' preferences, along the phases of renewable energy planning. A typical opinion trajectory departs from a very positive public sentiment (that is when people are not confronted with respective consequences), to much more critical (when a project is announced and consequences start to unfold) (Wolsink, 2007; Devine-Wright, 2005; van der Horst, 2007). In view of the unstable and constructed preferences, Wolsink (2007) has already highlighted more than a decade ago that there is a need for quantitative and methodological tools to operationalize public perceptions of wind farms. By developing a respective IS-tool, we aim at addressing this challenge. Thereby, we focus on onshore wind turbines in Germany, since the country has installed more wind turbines than any other European country (Wind Europe, 2019; NS Energy, 2019; Fleming, 2019).

3 Research Model and Hypothesis

As discussed above, we base our research model and hypothesis on decision-making theory and acceptance of renewable energies. Figure 1 illustrates our research model, where we proceed in two steps: 1) we evaluate citizens' decisions before interacting with the IS-tool, this is before visualising the decisions consequences. This value serves as a baseline and reflects citizens' ex ante constructed preferences. 2) We evaluate citizens' decisions after interacting with the IS-tool, which visualises the consequences of citizens' decisions. We aim at testing if the IS-tool significantly changes decisions. Thus, we formulate the following hypothesis in line with the above mentioned literature on decision-making, InfoVis, and acceptance of renewable energy (i.a., Bettman et al., 1998; Lurie and Mason, 2007; Wolsink, 2007): *Citizens' decisions on renewable energy change when respective consequences become clear.*

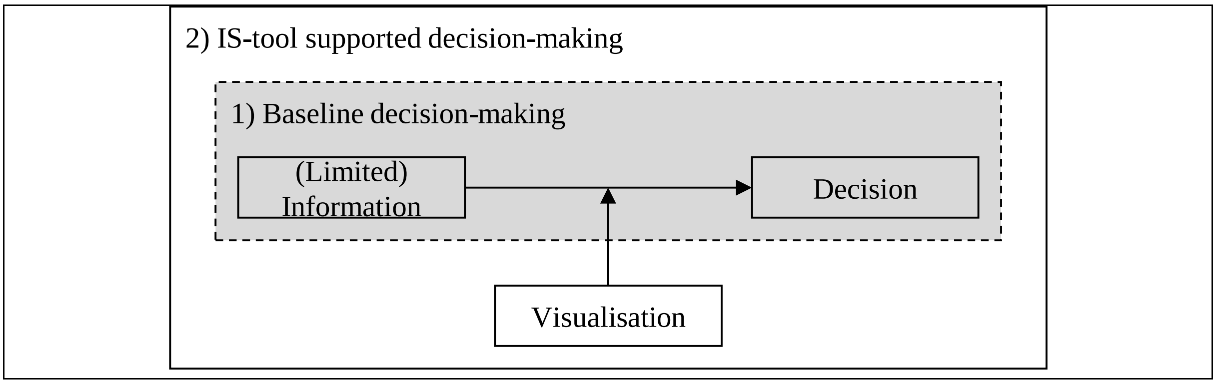

Figure 1. Research Model

We include the control variables *gender*, *age*, *level of education*, *residence* (country or city and Northern- or Southern-Germany), and *ecological attitude*. While the interpretation of most potential effects is less obvious, we include them in our analysis in line with previous literature that identified heterogeneity in decision-making and/or renewable energy acceptance (e.g., Pierce and Sweeney, 2010; Venkatesh and Morris, 2000; Tiefenbeck et al., 2016; Thompson et al., 1993; Hoen et al., 2019; Koivisto and Hamari, 2014; Johnson, 1990).

4 Method

4.1 Designing the Decision Tool as a Gamified System

For designing the decision tool, we choose a gamified system. To this end, we follow the '*Framework for Design and Research of Gamified Systems*' of Liu et al. (2017). The framework is based on a synthesis of existing literature and grounded on the individual level of analysis. According to the framework, a gamified system is defined as a target system (i.e., users, task, technology) to which gamification design elements (i.e., objects and mechanics) are added, in order to secure desired user-system interactions as well as a meaningful engagement. For yielding meaningful engagement with the system, Liu et al. (2017) suggest five gamification design principles. We summarize the operationalization of these principles in Figure 2 and describe them in detail in the following:

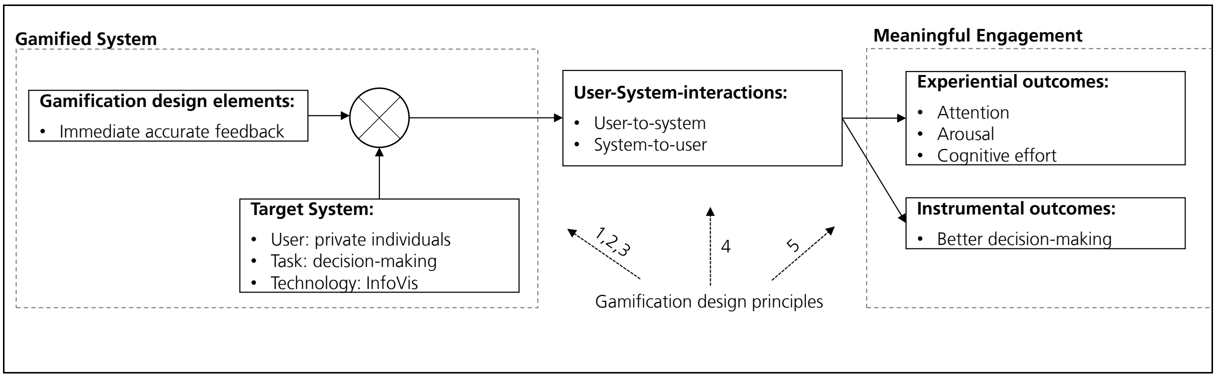

Figure 2. Design-principles of the IS-tool [these build upon Liu et al. (2017)]

First, *task congruence* refers to the fit of the gamified system with the target task to perform. In particular, a gamified system needs to be congruent to task characteristics. If so, users' engagement and satisfaction are increased. To yield task congruence, gamification design elements can be used to give task feedback. The target task to perform in the decision tool is decision-making. We ensure the system's congruence with this task as we provide immediate and accurate feedback on the decisions made and, thus, enable users to adapt decisions. Including such immediate feedback is one of the most dominant applications of gamification (Liu et al., 2017). Since renewable energy originally lacks feedback (see Section *Theoretical Background*), providing such compensates for this deficiency in the task design.

Second, *personalisation* refers to increasing the fit of the gamified system with the individual i.e., by focusing on the individual context. One way to comply with this principle is by analysing user-specific data for providing a tailored system design (Liu et al., 2017). The users of the decision tool are individual citizens. To yield personalisation, we tailor information and feedback provided by the decision tool to individual input provided at the start of interaction.

Third, *technology affordance* refers to the fit of the gamified system with the technology used. Specifically, this means that target system technologies should enable and facilitate gamification design features (Liu et al., 2017). The technology used by the decision tool to ensure this principle is an interactive map. This map visualizes existing and new wind turbines based on information provided by Open Street Map (www.openstreetmap.org) and the German weather service (Deutscher Wetterdienst, 2004) (see Section *Data Collection*).

Having addressed the fit of the system with task, individual, and technology in the first three principles, the fourth principle *dynamism* considers the production of desired user-system interactions. Thereby, interactions might be between user and system or, in the case of a multiuser system, also between users (Liu et al., 2017). The decision tool allows interactions between user-and-system only. Concerning the principle, we design those interactions in a way that allows users to make aesthetic experiences. Specifically, we include dynamic feedback as well as different colours (white and blue wind turbines).

Fifth, according to Liu et al. (2017), *meaningful engagement* refers to integrating experiential and instrumental outcomes. Specifically, a design system should not only provide some kind of experience but should also enhance instrumental, context dependent task outcomes. Since the decision tool includes a decision-making task, the intended *experiential outcomes* are attention, arousal, and cognitive effort (Liu et al., 2017). The intended *instrumental outcome* is an improved decision-making, which is in line with ones' true preferences. To ensure that the decision tool relates to these outcomes, we on the one hand provide visualized information on different aggregation levels (i.e., zoom levels) and on the other hand enable participants to correct their decision until they fully agree with resulting consequences.

4.2 Data Collection

To test the tool, we ran independent pre-test modes: First, we used personal contacts and gathered data from 85 academic researchers with expertise in decision-support systems, energy and critical infrastructures, sustainability, or individual behaviour in the IS context. About a quarter of them (i.e., 23) tested the tool in a face-to-face setting with one of the authors and directly provided their feedback.

The remaining 62 participants tested the tool themselves in live mode and returned their feedback afterwards. All data gathered in pre-tests was excluded from analyses (Summers, 2001).

For the main survey, we recruited 353 German participants from the online panel Consumerfieldwork. 200 were female, 152 male, and 1 participant did not want to specify the gender as female or male. 20.40% were below 35 years, 68.56% between 35 and 64 years, and 11.05% above 64 years. Approximately 29.18% were college educated. Further, since more wind turbines are located in Northern- than in Southern-Germany (Bundesverband WindEnergie, 2018), we aimed at considering both regions and related participants' perspective and thus recruited participants in a half-half split from the regions – see Appendix B (Table B1) for details. At the start of the survey, participants entered their postal code. Then, we confronted them with the fact that in 2016, coal-fired plants covered about 40% of the German electricity consumption (AG Energiebilanzen e.V., 2016). We asked them how many of these existing coal-fired plants they would replace with renewable wind energy – assuming they had free choice. An adjustable slider ranged from 0 to 100%. Please note that we are very well aware of the fact that the world is not quite as simple when it comes to replacing coal with wind power in the current electricity system and that many other factors play a role in this context. However, given a plethora of interesting variables, including all of them simultaneously is challenging within one research project and with the aim of answering a clear-cut research question. Given this challenge and for the sake of investigating whether the mechanism on which the tool is based produces research-relevant results, we have deliberately reduced the focus in our study, which also served as an indicator of whether the tool can successfully create an impact on citizens' decision-making process. Particularly, we have focused on the variable land use by wind power, which is a current topic in Germany in this context (Bauchmüller, 2019; Witch, 2019) (also see Section *Introduction* for details).

After submitting an answer, we confronted participants with a map of Germany illustrating the selected proportion of renewable wind energy in form of wind turbines emerging from the map. While white turbines illustrated existing turbines, blue turbines illustrated new turbines necessary for replacing coal-fired plants. If participants selected 0% in the previous question, only currently existing (i.e., white) wind turbines appeared. Further, participants could freely investigate the effects of their initial decision on the four different zoom levels *town*, *county*, *state*, *country (Germany)*. The initial zoom level at which the map of Germany appeared to the participant, was randomly determined with equal probability. We again asked participants for deciding upon the percentage of renewable wind energy. Before deciding, participants could 'play around' with the slider and received instant feedback on the consequences of their decision, as turbines were added or subtracted from the map on all zoom levels. Figure 3 illustrates this central part of the tool.

To determine the position of existing wind turbines, we used "OpenStreetMap" (www.openstreetmap.org). Therein, one can search for points of interest (nodes) and filter them by different attributes (tags). To locate the wind turbines, we focused on nodes within Germany having the tags power = generator and generator:source = wind. To approximate plausible positions of new wind turbines, we used information on wind speeds provided by meteorological maps of the German weather service (Deutscher Wetterdienst, 2004). Additionally, we considered legal and economic factors, defining rules such as minimum distances of wind turbines to residential areas or necessary wind speeds. Appendix C provides details on the approximation.

In accordance with our research model and hypothesis, we measured the following variables: As dependent variable, we first measured the percentage of coal-fired plants participants decided to replace with renewable wind energy. At the start of the survey, this variable referred to the initial percentage decided upon when participants did not see any consequences of their decision (i.e., variable name "Percent_Wind_0"). At the end of the survey, this variable referred to the last value chosen after participants saw the consequences of their decision in form of white and blue turbines on the map (i.e., variable name "Percent_Wind_1").

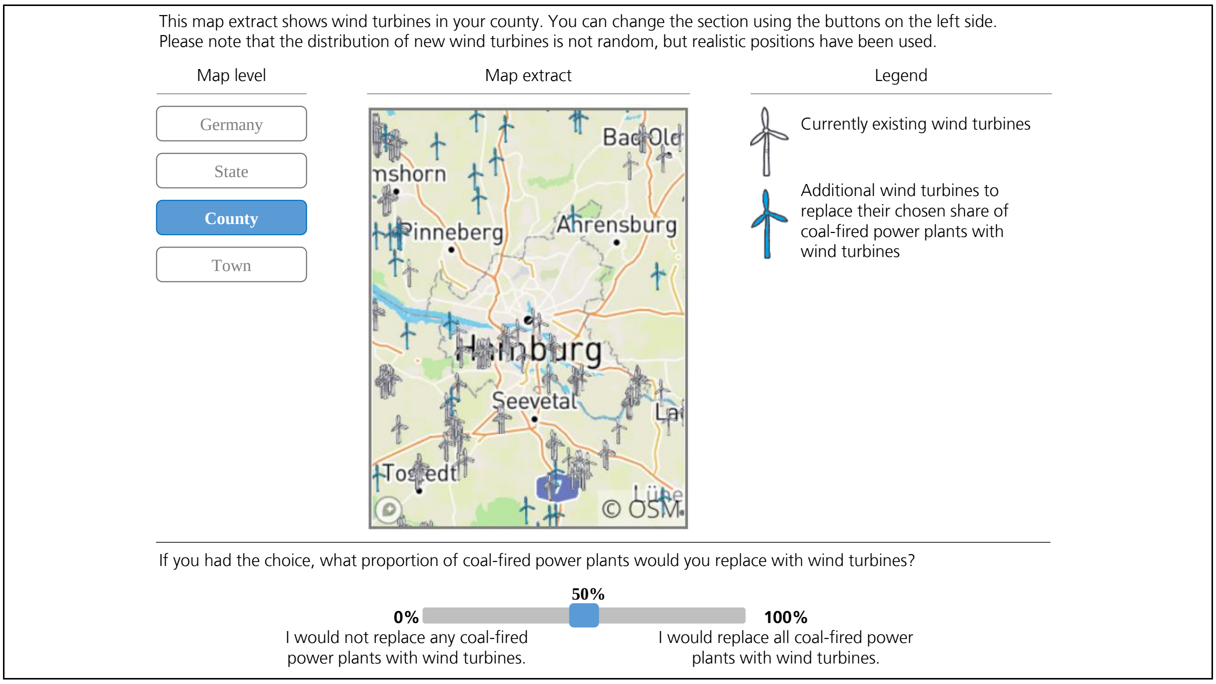

Figure 3. Illustration of the IS-Tool

As independent variables, we collected survey data on the participants' *gender*, *age*, and *education* as categorical (i.e., dummy) variables. Furthermore, we captured the participants' *ecological attitude* using a version of the New Ecological Paradigm scale (e.g., Bidwell, 2013), developed by Dunlap and his collaborators (Dunlap and van Liere, 1978; Dunlap et al., 2000). We used the scale as a single measure to capture participants' attitude regarding the balance of nature, limits to growth, and human domination of nature (Dunlap et al., 2000). Specifically, we calculated the average ecological attitude of all participants for this measure and classified citizens above this average as "*environmentally conscious*" and below this average as "*less environmentally conscious*." Further, we classified participants' location as (1) *Northern*- or *Southern-Germany* and (2) further classified their location as *city* or *countryside* with a list (excel-karte.de) categorizing German postal codes accordingly. Details are stated in Appendix B (Tables B1 and B2). We analyse the variables via a regression analysis.

5 Analysis and Results

First, we calculated the average percentage of coal-fired plants the 353 citizens would replace with renewable wind energy. This resulted in 72.15% for the 'Baseline'. Second, we conducted the regression analysis. Table 1 states the results for the start of the survey (i.e., 'Baseline'), which indicate a significant influence of *Age, Country/City*, and *Ecological Attitude* on participants' preference construction. In particular, participants between 35 and 64 years chose approximately 7% (i.e., 5.91 percentage points) less renewable wind energy than younger citizens in our sample. Citizens living in cities chose an energy mix that included approximately 10% (8.46 percentage points) more renewable wind energy. Further, less environmentally conscious citizens chose approximately 14% (11.50 percentage points) less renewable energy than environmentally conscious citizens did.

Independent Variables	Description	Dependent Variable Percent_Wind_0 (in %)	
Intercept		84.64	***
Gender	*Female*		
	Male	-3.84	
	Not specified	5.52	
Age	*<35*		
	35-64	-5.91	+
	>64	-0.50	
Education	*College educated*		
	Not College educated	-5.20	
Country/City	*Country side*		
	City	8.46	**
Northern/Southern Germany	*Northern-Germany*		
	Southern-Germany	-2.96	
Ecological Attitude	Environmentally conscious		
	Less environmentally conscious	-11.50	***

Notes: +p-value<0.10, *p-value <0.05, ***p-value<0.001

Table 1. Regression Results at the Start of the Survey (i.e., 'Baseline')

At the end of the survey, we again calculated the average percentage of coal-fired plants the 353 citizens would replace with renewable wind energy. This resulted in 65.45% for the 'IS-tool supported decision-making'. Once more, we conducted a regression analysis. Table 2 states the results that indicate a significant influence of *Education*, *Country/City*, and *Ecological Attitude* on participants' preference for renewable energy. In particular, participants without college education ended the survey with approximately 9% (i.e., 8.78 percentage points) less renewable wind energy than college educated citizens. Citizens living in cities chose an energy mix that included approximately 8% (6.04 percentage points) more renewable wind energy. Further, less environmentally conscious citizens chose approximately 13% (10.10 percentage points) less renewable energy than environmentally conscious citizens did.

Independent Variables	Description	Dependent Variable Percent_Wind_1 (in %)	
Intercept		77.73	***
Gender	*Female*		
	Male	-2.65	
	Not specified	10.26	
Age	*<35*		
	35-64	-3.34	
	>64	2.86	
Education	*College educated*		
	Not College educated	-8.78	*
Country/City	*Country side*		
	City	6.04	+
Northern/Southern Germany	*Northern-Germany*		
	Southern-Germany	-1.97	
Ecological Attitude	Environmentally conscious		
	Less environmentally conscious	-10.10	***

Notes: +p-value<0.10, *p-value <0.05, ***p-value<0.001

Table 2. Regression Results at the End of the Survey (i.e., 'IS-tool supported decision-making')

Additionally, we investigated the influence of the start value in the 'Baseline' (i.e., Percent_Wind_0) on the end value (i.e., Percent_Wind_1) in a regression analysis. Unsurprisingly, this initial relationship was strong and significant with an estimator of 0.87 and a p-value<0.001. This indicates that participants starting the survey with a higher percentage of renewable energy will end the survey with a high percentage of renewable energy. Although the preferred share of wind power at the start of the survey is a significant and strong predictor of the respective end value, we aimed at understanding participants' decision behaviour more precisely. Therefore, we tested whether differences between these two values changed significantly during the survey, indicating that participants have marginally revised their decision upwards or downwards. Given the small sample size in the sub samples and that respective data did not always meet requirements for normality, we conducted a Wilcoxon Signed-Rank test. The Wilcoxon Signed-Rank test is a non-parametric statistical hypothesis test that is used to compare repeated measures on a single sample and assesses whether the population mean ranks differ before and after an intervention or treatment calculating the differences between their ranks.

In addition to this statistical significance testing, we estimate the effect sizes of the start values on the end value. According to Cohen (1992), each statistical test has its own effect size index. The effect size for the Wilcoxon Signed-Rank test is a correlation coefficient (r) calculated by dividing the z statistic by the square root of N. Thereby, N equals the total number of observations (e.g., Pallant, 2007). The r value varies from 0 to close to 1. We evaluate the meaningfulness of this association by following Cohen (1992) who terms this effect size as small if $w \geq .10$, medium if $w \geq .20$, and large if $w \geq .40$.

Table 3 summarizes the mean and median of the variables Percent_Wind_0 and Percent_Wind_1 at the start (i.e., 'Baseline') and at the end of the survey (i.e., 'IS-tool supported decision-making') differentiated by employed independent variables. The table states the results of the Wilcoxon Signed-Rank test in form of significances and the effect sizes in the two last columns.

			Percent_ Wind_0		**Percent_ Wind_1**		**Wilcoxon Signed-Rank test**	
Variables	**Description**	**N**	**Mean**	**Med.**	**Mean**	**Med.**	**Sign**	**|r|**
Gender	Female	200	73.87	80.00	66.51	70.00	***	.25
	Male	152	69.90	80.00	64.03	70.00	***	.25
Age	<35	72	76.53	85.50	68.03	72.50	***	.28
	35-64	242	68.92	76.50	63.23	70.00	***	.25
	>64	39	76.53	85.50	68.01	72.50	***	.20
Education	College educated	103	75.79	84.00	71.34	80.00	**	.22
	Not College educated	250	70.65	80.00	62.98	69.00	***	.26
Country/City	Country side	206	67.71	70.00	62.08	67.00	***	.24
	City	147	78.37	90.00	70.17	80.00	***	.22
Northern/ Southern	Northern-Germany	185	75.08	76.50	63.23	70.00	**	.24
	Southern-Germany	168	68.92	80.00	62.98	69.00	***	.25
Ecological Attitude	Environmentally conscious	194	77.54	89.50	69.94	80.00	***	.26
	Less environmentally conscious	159	65.57	67.00	59.96	61.00	***	.23

Notes: **p-value<0.01, ***p-value<0.001

Table 3. Results of Wilcoxon Signed-Rank test

As the results in Table 3 indicate, there is a consistent and significant difference between the end and start value across all sub-groups. In particular, the end value is significantly lower than the start value of citizens – across all sub-samples. Further, effect sizes indicate that this 'downward correction' in value is small to medium.

6 Discussion

Too much information often leads to information overload, which in turn degrades the quality of decision-making. Current examples illustrate that this particularly has serious implications for policy decisions taken by citizens. We believe that the use of IS has the potential to improve decision quality.

Thus, this work sets out to design a gamified IS tool which interacts with the user by visualizing the consequences of decisions while guaranteeing meaningful engagement. The performance of the tool is exemplarily tested in context of renewable energy in Germany. Specifically, we ask a sample of 353 German citizens to select the percentage of coal-fired plants participants they wish to replace with renewable wind energy. Once selected, the tool immediately visualizes the selected percentage of wind turbines on a map of Germany. We apply regression analyses along with non-parametric tests to analyse gathered data. This yields the following three key findings:

First, the IS tool draws a realistic picture of citizens' preferences for renewable energy in Germany. Results indicate that young, urban, and environmentally aware citizens are willing to accept a high percentage of renewable wind energy. Specifically, we find the variables *Age*, *Country/City*, and *Ecological Attitude* to be significant predictors of the dependent variable *Percent_Wind_0* (i.e., 'Baseline'). This result reflects trends and socio-economic developments at the time when the survey was conducted. Examples include the #FridaysForFuture-movement. The hashtag describes an international movement of young citizens (i.e., students) who strike for the climate instead of attending school. Another example are the 2019 European elections in Germany, during which the Green Party, which promotes renewable energies, received support from young citizens in particular (Der Bundeswahlleiter, 2019b, 2019a).

Second, and this is the main finding, results indicate that the tool influences citizens' decisions making. In particular, we find that all analysed cross-sections of citizens within our sample change the amount of renewable energy initially desired, after interacting with our tool. On average, the percentage of renewable energy is reduced by approximately 9% (72.15% average start value and 65.45% average end value). In fact, after interacting with the tool, citizens select less renewable energy than initially. Taking this further, this finding might imply that people agree less with something, as soon as they are able to see the implications of it. According to existing literature (e.g., Irvin and Stansbury, 2004), future political actions considering citizens' decision in terms of the revised preferences might then receive a higher level of support.

Third, the tool does not completely turn over decisions. In particular, results highlight the value of the variable *Percent_Wind_0* selected before interacting with the tool to be a strong and significant predictor of *Percent_Wind_1* end value. This indicates that individuals preferring high levels of renewable energy before interacting with our tool still do so afterwards and vice versa. There may be many scientific explanations for this: one refers to the scientific notion of the confirmation bias, making users to stick to their initial decision and hence, classify new information accordingly (Nickerson, 1998).

6.1 Implications

Considering the three key findings outlined, the implications of this work are both, theoretical and practical. Concerning the theoretical implications, it is to say that this research is positioned at the confluence of two fields of research, which are decision-making and IS. Linking these two research fields provides decision-theory researchers with an increased understanding and empirical evidence of the utility and suitability of IS tools for supporting human decision-making in a citizen context. IS researchers, however, get an understanding of how IS including InfoVis technologies influences decision-making, which enables them to support similar political decisions situations in the citizen context. Such similar decision-situations include elections of parties or political representatives, referendums of political independence, and votes on legislative proposals or actions of any kind – not only restricted to the context of energy but also in the context of healthcare, taxation, or education. In terms of practical implications, this work enables policy makers to formulate regulations, which are more realistically grounded in citizen's preferences, which are constructed on a broader set of information through tool interaction. What follows therefrom are future projects, which might receive improved support from the public and create less resistance – a calculation that underlies the involvement of citizens in political decisions (Irvin and Stansbury, 2004). We believe that the strengthening of the calculation will lead to an improved involvement of citizens in political decisions, even in countries where it was previously not customary. Hence, this research ultimately serves citizens by promoting an inclusive society where they get a voice in various decision-making.

6.2 Limitations

Like any study, the present study has several limitations, referring to 1) the goal of this research paper, 2) the design procedure of the IS tool, 3) the chosen application context, and 4) the validation procedure, which leaves room for further investigations by fellow researchers.

Concerning 1), the research goal is to develop an IS tool that directly confronts people with the consequences of their decisions in different citizen contexts. In the applied context of wind energy, there are of course many variables to consider. However, our research goal was not to design an IS tool that comprehensively informs German citizens about wind power and including all the complexity. Instead, we made a deliberate decision to narrow the focus to specific aspects for the sake of a clean research design and clear research question. More precisely, we focus on the variable land use by wind power, which is a current topic in Germany's wind context. However, the findings reported in this paper should encourage further research to extend this work and explore additional aspects in more detail, such as local pollution, air-quality, health issues, grid development, storage, CO2, global warming, etc. Further, future research might also expand the research by exciting related aspects, such as the dangers of a blackout that come with the coal exit (Wetzel, 2020).

Cornering 2) the design of our IS tool, it is to say, that we adhered to the design principles for gamified IS suggested by Liu et al. (2017). Future research, however, could also consider the inclusion of further principles such as principles of Green IS as proposed by, Seidel et al. (2013), Mustaquim and Nyström (2013, 2014), Recker (2016), or Seidel et al. (2018). Even though some of these principles refer to an organizational level instead of an individual one, future research could map them against the principles we have already considered. Besides including further principles, the design of the proposed IS tool could also be enhanced by changing the concrete implementation of those. For example, the implementation of the personalisation principle could be intensified by further research demanding more input from individuals at the beginning of the survey, according to which feedback is then tailored. Finally, future studies could explore additional ways, beyond an IS tool, to support individuals on a citizen level with decision-making.

Concerning 3) the chosen application context, it is to say that the current study builds on data of *353* individuals living in Germany. We cannot guarantee the results to be stable in contexts or samples beyond the ones considered within this study. This is because renewable energy decision-making might be influenced by different factors, such as contextual or cultural ones. Therefore, we suggest further research to investigate the evidence of our findings in other settings.

Concerning 4) the validation procedure, limitations derive from the conducted survey and the applied method of analysis. First, within the survey, future research could apply further measures, enabling an improved understanding of the variables and their impact on the decision at hand. Second, and beyond the limitations mentioned so far, this work is also limited by the assumptions associated with the use of such an IS tool. Thereby, the access to and the acceptance of the technology on which the tool is based upon should be mentioned as examples.

7 Conclusion

In times of technological revolution and associated information overload, citizens focus on salient aspects when making political decisions, rather than utilizing all information available. Following therefrom are decisions that fail to reflect true preferences. A situation that may be alleviated through decision-support. Accordingly, this work designs an IS tool for decision-support relying on gamification principles for meaningful engagement as well as InfoVis as underlying technology. Once built, the IS tool is applied to the context of renewable energy in Germany. Three key findings are derived: First, the tool is able to replicate realistic preferences in terms of citizens' acceptance of renewable energy in Germany. Second, all citizens interacting with the tool reduce the preferred level of renewable energy.

Third, we find that tool interaction changes initial decisions. The insights derived within this work increases the understanding of citizens' decision-making. Thereby, on a meta-level, this work contributes to an increasingly inclusive world, within responsive, participatory, and representative decision-making at all levels.

8 Appendices

8.1 Appendix A

This appendix references a *Supplementary Material*, which serves the reader as additional information but is not required for a sound understanding of this article. Please use the following link https://www.dropbox.com/scl/fi/5z9a53xubxhcbdzptu168/Tool_Documentation.docx?dl=0&rlkey=pfljvoxmp6rms99i0xtgm5a5j to see the a documentation (i.e., screenshots) of the IS tool.

8.2 Appendix B

Table B1: Classification of Participants' Residency as Northern-/Southern-Germany

Region	Sample size	Federal state	Sample Size
Northern-Germany	185	Northern Niedersachsen	39
		Schleswig-Holstein	35
		Hamburg	38
		Bremen	37
		Mecklenburg-Vorpommern	36
Southern-Germany	168	Baden-Württemberg	82
		Bayern	168

Table B2: Classification of Participants' Residency as Country/City

Region	Sample size	City or country	Sample Size
Northern-Germany	185	City	99
		Country side	86
Southern-Germany	168	City	48
		Country side	120

8.3 Appendix C: Details on the Calculating the Position and Number of New Wind Turbines

Details on calculating the position:

The calculation was primarily based on data and information from the German weather service (Deutscher Wetterdienst, 2004), which provides maps with average annual wind speed in 80-metre height. This height is close to the hub height of commonly used wind turbines like the Vestas V 90 (80m – 105m depending on the model). Whether a position is suited for wind turbines was based on information provided by Fachagentur Windenergie (2019b), which summarises and constantly updates legal and economic factors (e.g., minimum distance of wind turbines) for all federal states of Germany. We based our calculation on the 2017 version (slightly updated version of 2019 available, cf. Fachagentur Windenergie, 2019a). We averaged information (e.g., minimum distance affordances) across all federal states. On this information basis, we used OMS and Python to determine if a position fell into a restricted area. Wind speeds below 3 meters per second are not economically viable and therefore excluded. From the remaining positions, 17000 are randomly selected based on a linear distribution depending on the wind speed. This resulted in a list of random coordinates within Germany and the wind speed at their respective position.

Details on calculating the number of new wind turbines:

In 2016 coal-fired plants in Germany produced 250 terawatt-hours of electricity (AG Energiebilanzen e.V., 2016), which would need to be replaced by wind turbines in our survey. Thus, for estimating the number of wind necessary turbines, we estimated the yearly production of one wind turbine, considering the average annual wind speed in Germany.

9 References

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