

Welling, Malte; Zawojka, Ewa; Sagebiel, Julian

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## Information, consequentiality and credibility in stated preference surveys: A choice experiment on climate adaptation

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# Information, consequentiality and credibility in stated preference surveys

## A choice experiment on climate adaptation

Malte Welling · Ewa Zawajska · Julian Sagebiel ·

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**Abstract** Information provided in valuation surveys has been shown to affect stated preferences, which in turn may matter for the validity and reliability of survey-based value estimates. Although such information effects are widely documented, the reasons underlying the effects are less established. We examine two pathways which might explain information effects in stated preferences, using additional information about a climate adaptation strategy as an experimental treatment in a choice experiment on nature based climate adaptation measures in the German city of Bremen. We hypothesize and empirically analyze whether information effects can emerge as a result of changed perceptions (1) about the credibility of the scenario and (2) about the survey consequentiality upon facing additional information. We find that the additional information strengthens perceived credibility of the scenario and strong credibility perceptions increase value estimates. In our study, the role of the information on consequentiality perceptions appears to be negligible.

**Keywords** environmental valuation · discrete choice experiment · information effects · perceived consequentiality · perceived credibility · urban ecosystem services ·

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Malte Welling

Institute for Ecological Economy Research, Berlin, Germany and Brandenburg University of Technology, Chair of Environmental Economics, Cottbus, Germany

E-mail: [malte.welling@ioew.de](mailto:malte.welling@ioew.de)

Ewa Zawajska

Faculty of Economic Sciences, University of Warsaw, Warsaw, Poland

E-mail: [ewa.zawajska@uw.edu.pl](mailto:ewa.zawajska@uw.edu.pl)

Julian Sagebiel

Department of Economics, Swedish University of Agricultural Sciences, Uppsala, Sweden

E-mail: [julian.sagebiel@slu.se](mailto:julian.sagebiel@slu.se)

## 1 Introduction

Stated preference surveys are used to measure the value of public goods to society. Despite their broad application in environmental economics and other areas, a remaining concern is the validity and reliability of stated preference value estimates. One of several factors shown to matter for stated preferences and potentially affecting the validity and reliability of the value estimates is the type and amount of information provided to survey respondents before preference elicitation (Blomquist and Whitehead 1998; Munro and Hanley 2001; Johnston et al. 2017). While the importance of information provision is well established, less is known about the reasons underlying information effects. This paper investigates two new potential pathways of the effect of information conveyed through textual scripts before preference elicitation. We refer to this kind of text as information scripts throughout the paper.

The effects of information scripts on stated preferences have been researched for many years. The majority of studies find that additional information about the good to be valued increases the value estimates (e.g., Hoevenagel and Linden 1993; Munro and Hanley 2001; Bateman and Mawby 2004). Varying the way how the information is provided is also shown to affect stated preferences (e.g., Ajzen, Brown, and Rosenthal 1996; Czajkowski, Hanley, and LaRiviere 2016; Yang and Hobbs 2020). Yet, the empirical evidence is not consistent. A few studies report no or very limited effects of additional information about the good to be valued (e.g., Berrens et al. 2004; MacMillan, Hanley, and Lienhoop 2006; Needham et al. 2018).

The literature does not provide a consistent explanation for information effects. The effects of information scripts on stated preferences can emerge through various pathways. Munro and Hanley (2001) argue that respondents rationally adapt their decisions after learning about the benefits from the environmental good, which leads to higher value estimates. Similarly, Bergstrom, Stoll, and Randall (1990) develop a theoretical model showing that information about the benefits from the environmental good can influence willingness to pay by altering the perceived marginal utility from the good. This is in line with findings by Hoehn and Randall (2002) and Hasselström and Håkansson (2014) that additional information affects only those respondents for whom the information is new and the conclusion by Bateman and Mawby (2004) that the effect of additional information is particularly strong for

goods that are unfamiliar. On the other hand, Hoevenagel and Linden (1993) suggest that respondents use availability heuristics, as specified by Tversky and Kahneman (1974), to simplify the preference elicitation task: respondents assign greater importance to attributes with more extensive information. Other authors explain information effects with directional context effects: The survey methodology literature finds that questions displayed earlier in a questionnaire may provide an interpretative framework influencing responses to questions asked further in the survey (Tourangeau and Rasinski 1988; Tourangeau, Rips, and Rasinski 2000; Moore 2002; Dillman 2011). In the context of stated preferences, Pouta (2004) and Liebe et al. (2016) show that asking attitudinal questions before eliciting preferences can increase the value estimates. Information scripts could provide a similar interpretative framework. Finally, experimenter demand effects might partly explain the influence of information scripts. This concept refers to respondents adapting their behavior according to cues about how the experimenter may expect them to behave (De Quidt, Haushofer, and Roth 2018). Information scripts could constitute such a cue for respondents about expected responses in the preference elicitation task.

We argue there could be other possible pathways leading to information effects, which, to the best of our knowledge, have not been addressed in the stated preference literature so far. One of such pathways is that information scripts may affect respondents' perceptions of the survey consequentiality, which, in turn, can matter for stated preferences. Consequentiality has been identified as a necessary condition for truthful preference disclosure and, therefore, is required for valid value estimates (e.g., Vossler, Doyon, and Rondeau 2012; Carson, Groves, and List 2014). A survey is consequential when there is a positive probability that the survey results will influence the decision of policy makers regarding the provision of the considered good and the collection of the payment related to this provision (Carson and Groves 2007; Johnston et al. 2017). Most previous studies find that stated preference value estimates increase with the strength of the consequentiality belief (Herriges et al. 2010; Vossler and Watson 2013; Groothuis et al. 2017; Vossler and Holladay 2018).<sup>1</sup> If information scripts influence consequentiality perceptions (as some consequentiality scripts are shown to do; e.g., Oehlmann and Meyerhoff (2017)), the effects of information scripts on stated preferences could be then partly explained by this indirect pathway of shifted consequentiality perceptions.

Another unexplored pathway could be through respondents' perceptions of the credibility of a public good policy scenario considered in the survey. These perceptions are likely influenced by information scripts and at the same time they may affect stated preferences. Johnston et al. (2017) note that three types of information should be seen as credible by respondents in order to derive valid value estimates from stated preference surveys: the information about the current state, about the mechanism of the proposed policy change and about the extent of the policy change. Kataria et al. (2012) investigate to what extent respondents believe in the provided information about the current state and the policy change. They find that respondents who view the information as more credible have a higher willingness to pay for improving river water quality. In contrast, Vasquez and Rezende (2019) do not find significantly different willingness to pay among those who perceive the presented current state of water quality as more credible. If information scripts influence perceived credibility and these perceptions affect stated preferences, this pathway could also partly explain information effects.

The aim of this paper is to investigate the two pathways of consequentiality and credibility perceptions that may potentially explain a change in stated preferences upon provision of information scripts. To the best of our knowledge, no previous research has investigated the roles of consequentiality and credibility perceptions for explaining information effects. The study utilizes data from a discrete choice experiment survey conducted in April and May 2019 on a representative sample of 1,276 residents of the city of Bremen in Germany. The survey elicits respondents' preferences towards extending urban green spaces as a climate change adaptation measure. To address the research question, we design two randomly assigned survey versions that differ with respect to the information displayed before eliciting preferences. Both versions provide necessary information for understanding the valuation scenario. One version, in addition, presents extended information about the policy context of the adaptation measures. We estimate mixed logit and hybrid mixed logit models to analyze how the script affects stated preferences, how the script shifts consequentiality and credibility perceptions, and how these perceptions matter for stated preferences.

Our study proposes a novel framework for analyzing how information scripts affect stated preferences. It may improve understanding of the mixed evidence on information effects in the literature.

Results of our analysis can also deliver important insights for stated preference practitioners in constructing balanced information scripts. Understanding mechanisms that lead information effects to emerge is essential for correctly designing stated preference studies and for obtaining valid value estimates to support public decision making. Information provided in the surveys could plausibly affect perceptions of consequentiality and credibility. Findings on the importance of these pathways in explaining information effects can guide decisions on which information to provide about the good to be valued. Moreover, the study contributes to the line of research on the validity of stated preference methods. It provides additional evidence on the role of consequentiality perceptions and the little studied credibility perceptions for willingness to pay. Results may inform stated preference practitioners on whether and how these desirable characteristics of a valuation survey can be strengthened with information scripts.

## 2 Empirical data

The survey was conducted in the German city of Bremen and implemented online. It elicited preferences of residents towards extending urban green spaces as a climate change adaptation measure. The value estimates were used in a cost-benefit analysis of the climate change adaptation strategy for the city. The survey provided respondents with detailed information about the considered policy scenario and the attributes characterizing it. Half of respondents received additional contextual information about the climate change adaptation strategy of the city. After the information, respondents participated in a discrete choice experiment. Follow-up questions queried about respondents' perceptions about the survey consequentiality and the credibility of the policy scenario. The questionnaire ended with socio-demographic questions.

### 2.1 Discrete choice experiment

The survey considered a citywide policy aimed at extending urban green spaces. The policy was characterized by five attributes, as presented in Table 1. The final selection of the attributes, their levels and definitions were guided by expert insights from the city administration collected in two

workshops. The selection was tested in an online pretest with 115 respondents recruited from an online panel.

[TABLE 1 APPROX HERE]

The attributes included the number of street trees per 100 meters, the share of green areas in the city's total area, the share of extensive green roofs (i.e., those with thin substratum), the share of intensive green roofs (i.e., those with thick substratum) and an annual cost per individual. Each of the four non-cost attributes took one of three possible levels. For each attribute, one of the levels corresponded to the current average level in the city. The two other levels represented extensions compared to the current situation. The status quo levels were derived from geographic information system data and were verified by experts from Bremen's public administration. The monetary attribute was defined as a compulsory yearly payment for every resident of the city that the city would collect and spend exclusively on the development and maintenance of the urban green.

The attributes were explained in detail on separate screens of the survey prior to the discrete choice experiment. Respondents were informed about the current average levels in Bremen for each non-monetary attribute and these levels were labelled as "As today" in the discrete choice experiment.

The discrete choice experiment consisted of a sequence of nine choice tasks. Every task included two policy alternatives and a status quo alternative, out of which respondents were asked to choose their most preferred option. The right-hand side alternative was always the status quo labelled as Current state, with all non-cost attribute levels set to the current city average levels and no cost. The two policy alternatives involved changes to the current state and were named as Combination A and Combination B. The cost for the hypothetical alternatives ranged between 5 and 400 Euro. Figure 1 shows an example choice task.

[FIGURE 1 APPROX HERE]

The design involved 36 choice tasks split into four blocks. Each respondent was presented with a randomly assigned block of nine choice tasks. The design was created with the Stata module `dcreate`, using the modified Fedorov algorithm to maximize the D-efficiency for dummy coded attributes in a

multinomial logit model (Hole 2017). Priors from the pretest were used. The design was compared to various other designs and tested via simulation in terms of efficiency and bias.

## 2.2 Information script treatments

Before the discrete choice experiment, all respondents were provided with information about the good to be valued and its characteristics. The information included a description of the five attributes, current levels of the attributes in Bremen and expected effects of the proposed changes in the attribute levels on the cityscape, leisure usability, biodiversity, water retention and heat mitigation. Respondents were further reminded via a standard script that the city administration would implement the policy and collect the payments depending on the survey outcome.

The survey involved two randomly assigned treatments that differed in whether additional information about the policy context was provided or not. Half of respondents were assigned to the *No Script* sample and did not see any additional information. The other half of respondents were assigned to the *Script* sample and were shown an additional script before the choice tasks describing the city's climate change adaptation strategy and expected impacts of climate change. The script reads as follows:<sup>2</sup>

*The Senate of Bremen adopted the climate change adaptation strategy for Bremen in April 2018. The strategy document explains the consequences of climate change for the city of Bremen. Strong rain, river and storm floods will become more likely. The strategy document predicts a rising risk of flooding with property damages, such as flooded basements and underground garages. According to the strategy document, heat waves will also become more likely. These can reduce your productivity and strain your cardiovascular system.*

The treatments further differed in explaining the policy context of the considered attributes. Only respondents in the *Script* sample were explicitly told that the considered urban green measures were part of the city's climate change adaptation strategy. The difference in the survey script was as follows:

No Script: *The first part of this survey focuses on possible urban green measures for the city of Bremen.*



*Script: The climate change adaptation strategy mentions several measures which the city of Bremen could apply. The first part of this survey focuses on some of these measures.*

Other than the two differences in the survey script explained above, the survey questionnaires used in the treatments were exactly the same. In the remainder of the paper, we refer to the additional information provided to the *Script* sample respondents as the information script.

### 2.3 Elicitation of perceptions of consequentiality and credibility

Information about perceived consequentiality and credibility was collected after the discrete choice experiment. Although related, consequentiality and credibility are distinct concepts. Consequentiality refers to the survey responses having actual consequences by influencing final decisions of policy makers, while credibility refers to the proposed changes being plausible in general.

Recent works suggest that consequentiality perceptions could be elicited with the use of questions that differentiate between respondents' perceptions towards policy consequentiality and payment consequentiality (e.g., Vossler and Holladay 2018; Zawojcka, Bartczak, and Czajkowski 2019). Following the definition in Johnston et al. (2017), policy consequentiality can be understood as a positive probability that survey responses will influence decisions related to the outcome in question; payment consequentiality corresponds to a positive probability that the payment for the considered project will be collected if the project is implemented.

We used two questions targeting the measurement of perceived policy consequentiality and perceived payment consequentiality, respectively: "To what degree do you believe that your responses will affect which measures will be implemented in the city of Bremen?"; "To what degree do you believe that your responses will affect whether you will have to pay the additional cost if the measures are implemented?". The Likert response scale included six levels labelled as "I strongly believe", "I rather believe", "I neither believe, nor do not believe", "I rather do not believe", "I do not believe at all", and "I do not know".

Similarly to Kataria et al. (2012), we collected data on perceived credibility of the policy change, by querying respondents about the likelihood that the proposed changes could be realized. For each of

the four non-cost attributes we asked: “How likely do you think it is that the proposed extent of the changes can actually be realized?”. The Likert response scale included six levels labelled, respectively, as “very likely”, “rather likely”, “neither likely nor unlikely”, “rather unlikely”, “very unlikely”, and “I do not know”.

## 2.4 Survey implementation

The selection of the attributes, their levels and descriptions were guided by the expertise of administration officials of the city of Bremen. Two workshops with representatives of the city administration took place in June and October 2018 and additional interviews were conducted in follow-up bilateral meetings and phone calls. The questionnaire was then developed under consultation with representatives from the general population through personal interviews. A pilot study with 115 respondents was used to assess and improve the questionnaire and the experimental design.

The final survey was implemented online as Computer-Assisted Web Interviews (CAWI) and consisted of 52 screens. The survey was administered by a professional public opinion polling agency from April to May 2019. 1,276 residents of Bremen and adjacent districts completed the questionnaire. Participants were recruited with two modes. Firstly, 1,011 respondents belonged to a panel that the polling agency recruited offline without the possibility of self-enrollment. Secondly, to increase the sample size, 5,000 letters with a link to the online survey were sent via mail to a random sample of home addresses provided by the city of Bremen. 265 additional respondents were recruited this way. For the empirical analysis, we excluded 98 respondents who responded “I do not know” to at least one of the questions on consequentiality and credibility perceptions. Therefore, our investigation below is based on a sample of 1,178 respondents.

Table 2 shows socio-demographic characteristics of the respondents, separated into the *Script* and *No script* samples. Differences in these characteristics between the two samples are negligible. A t-test for the difference in means for age and  $\chi^2$ -tests for differences in shares for the remaining characteristics indicate no statistically significant differences between the treatment groups.

[TABLE 2 APPROX HERE]

### 3 Econometric approach

We estimate two models to answer the research question whether information effects in stated preference surveys can arise because of information-induced changes in perceptions about the survey consequentiality and the policy scenario credibility. Model I is a mixed logit model (Greene 2011) and uses only the collected data on stated preferences. Model II is a hybrid choice model and uses the data on both the stated preferences and the perceptions, also known as an integrated choice and latent variable approach (Ben-Akiva et al. 2002). Model I is equivalent to the discrete choice component of Model II with a null latent variable vector. For this reason, the description below focuses on a more general, hybrid choice modelling framework.

A hybrid choice model is a flexible tool that allows for including unobservable characteristics of individuals, such as perceptions about consequentiality and credibility, into a random utility framework. The unobservable perceptions enter the model indirectly as latent variables, since direct inclusion of self-reported measures of the perceptions in choice models may lead to econometric issues, such as a measurement error. Hybrid choice models are being increasingly used to analyze choice behavior of individuals in the area of environmental economics (e.g., Faccioli et al. 2020; Abate et al. 2020) and elsewhere (e.g., Thorhauge et al. 2019; Schmid and Axhausen 2019; Albaladejo and Diaz-Delfa 2020; Golkebiowska, Bartczak, and Czajkowski 2020). In our study, we employ a hybrid choice mixed logit approach as proposed by Czajkowski et al. (2017), which combines the standard mixed logit model (Greene 2011) with the multiple indicators and multiple causes model (Jöreskog and Goldberger 1975). We use the hybrid choice model to find a relationship between the information treatment, respondents' unobservable perceptions about the consequentiality and credibility, and their preferences towards the considered green climate change adaptation measures in Bremen.

The hybrid choice model employed in our study involves three components: a discrete choice model part, structural equations and measurement equations. The components are estimated simultaneously and linked by latent variables that are used to capture unobservable perceptions of respondents. We consider two latent variables: the first one is assumed to explain Likert-scale responses to the four questions querying about respondents' perceptions about credibility of the considered policy scenario

attributes; and the second one is assumed to explain Likert-scale answers regarding respondents' perceptions about the two aspects of the survey consequentiality (i.e., policy and payment consequentiality). For ease of representation, we henceforth refer to these variables as latent credibility and latent consequentiality, respectively. In the measurement equations, correlations between the latent variables, which capture directly unobservable perceptions of the respondents, and indicator measures of the underlying unobservable perceptions are modelled. For each latent variable, there is one structural equation. In the structural equations, the information treatment variable is used to explain potential variation in the respective latent variable. The discrete choice component is a mixed logit model that additionally includes the information treatment, latent credibility and latent consequentiality to explain possible shifts in means of the preference parameters. Each of these three components of the hybrid choice model is presented in detail below.

### 3.1 Discrete choice component

The discrete choice component depicts the decision process of respondents when making a selection in the discrete choice experiment. Modelling of preferences disclosed through such choices is typically based on a random utility framework (McFadden 1974). According to the framework, the utility of individual  $i$  from selecting alternative (policy scenario)  $j$  in choice task  $t$ ,  $U_{ijt}(\cdot)$ , depends on observed characteristics of the policy, including non-monetary choice task attributes,  $X_{ijt}$ , and a monetary attribute, cost  $C_{ijt}$ , and on unobserved idiosyncrasies represented by a stochastic component  $e_{ijt}$ . Formally, it can be written as

$$U_{ijt}(\cdot) = \beta_i' X_{ijt} - \alpha_i C_{ijt} + e_{ijt} \quad (1)$$

where  $\beta_i$  is a vector of individual-specific preference parameters (i.e., marginal utilities from the policy attributes) and  $\alpha_i$  is a cost parameter representing marginal utility of income. All marginal utility parameters are individual-specific, as suggested by indexing over  $i$ . This allows for heterogeneous preferences among respondents, leading to the mixed logit specification. Instead of estimating the marginal utility parameters separately for every respondent, we follow the standard practice and assume

that the parameters are from a multivariate distribution, and allow for non-zero correlation of the parameters (Train 2009).

The underlying model in (1) may be estimated in either preference space or willingness to pay space (Train and Weeks 2005). Both specifications are behaviorally equivalent, but when estimating the model in willingness to pay space, preference parameters can be readily interpreted as willingness to pay amounts (i.e., implicit prices). We employ this approach. To derive the willingness to pay space model, we first divide all arguments in (1) by the logit scale parameter  $\theta_i$  to get

$$U_{ijt}(\cdot) = \boldsymbol{\gamma}_i' \mathbf{X}_{ijt} - \lambda_i C_{ijt} + \epsilon_{ijt} \quad (2)$$

where  $\boldsymbol{\gamma}_i = \frac{\beta_i}{\theta_i}$  is a vector of preference-space coefficients on non-monetary policy attributes,  $-\lambda = \frac{-\alpha_i}{\theta_i}$  is a preference space coefficient on the policy cost, and  $\epsilon_{ijt}$  is an error term with an i.i.d. type I extreme value distribution and constant variance  $\text{var}(\epsilon_{ijt}) = \frac{\pi^2}{6}$  (Scarpa, Thiene, and Train 2008; Train and Weeks 2005).

Marginal willingness to pay values for changes in the non-monetary policy attributes can be calculated as a ratio of the coefficients on these non-monetary attributes and the cost coefficient, that is, as  $\omega_i = \frac{\gamma_i}{\lambda_i} = \frac{\beta_i}{\alpha_i}$ . We thus reformulate (2) to obtain the willingness to pay space specification (Train and Weeks 2005),

$$U_{ijt}(\cdot) = \lambda_i \left[ \left( \frac{\boldsymbol{\gamma}_i'}{\lambda_i} \right) \mathbf{X}_{ijt} - C_{ijt} \right] + \epsilon_{ijt} = \lambda_i [\boldsymbol{\omega}_i' \mathbf{X}_{ijt} - C_{ijt}] + \epsilon_{ijt} \quad (3)$$

The elements of vector  $\boldsymbol{\omega}_i$  are random coefficients assumed to be normally distributed. To ensure a positive marginal utility of income, we follow the standard practice and define  $\lambda_i = e^{\nu_i}$ , where  $\nu_i$  is the underlying latent normal factor that specifies the lognormally distributed cost coefficient (Scarpa, Thiene, and Train 2008; Thiene and Scarpa 2009).

In order to investigate the relation of consequentiality and credibility perceptions with stated preferences, we extend (3) to allow the random coefficients to be a function of individual-specific latent

variables, denoted by vector  $\mathbf{LV}_i$  (i.e., latent credibility and latent consequentiality), and information treatment variable  $S_i$ . We hence specify the vector of willingness to pay parameters as

$$\boldsymbol{\omega}_i = \boldsymbol{\omega}_i^* + \boldsymbol{\delta}' \mathbf{LV}_i + \varrho S_i \quad (4)$$

where  $\boldsymbol{\omega}_i^*$  has a multivariate normal distribution with a set of means and a covariance matrix to be estimated;  $\boldsymbol{\sigma}$  and  $\varrho$  are vectors of parameters to be estimated and  $S_i$  is a binary variable that takes a value of one if respondent  $i$  faced the additional information script and zero otherwise.

Following the same notation, we redefine the cost coefficient as

$$\lambda_i = e^{\nu_i + \boldsymbol{\psi}' \mathbf{LV}_i + \tau S_i} \quad (5)$$

with parameters  $\boldsymbol{\psi}$  and  $\tau$  be estimated.

### 3.2 Measurement component

Latent variables in hybrid choice models are used to capture individual characteristics that are not directly observable and cannot be objectively measured. Instead of exact measures, the models rely on the use of indicators of the unobservable characteristics, which are expected to be correlated with the latent variables. Hence, in the measurement equations, the two latent variables are used to explain respective indicators on the perceived survey consequentiality and the perceived policy scenario credibility. Given the discrete and ordinal nature of the indicators (Likert-scale responses), we specify the measurement equations as ordered probit regressions. Formally, this relationship can be represented as

$$\mathbf{I}_i^* = \mathbf{LV}_i \boldsymbol{\Gamma} + \boldsymbol{\eta}_i \quad (6)$$

where  $\mathbf{I}_i^*$  is a vector of the indicator variables (i.e., measures of the unobservable perceptions),  $\boldsymbol{\Gamma}$  is a matrix of coefficients to be estimated and  $\boldsymbol{\eta}_i$  denotes a vector of error terms assumed to come from a multivariate normal distribution with zero means and an identity covariance matrix. The dependent

variables in vector  $\mathbf{I}_i^*$  on the left-hand side of (6) are characterized by five ordered levels, corresponding to different levels of agreement with Likert-scale questions, which can be written as

$$\begin{aligned}
 \mathbf{I}_i &= 1 \text{ if } \boldsymbol{\mu}_0 < \mathbf{I}_i^* \leq \boldsymbol{\mu}_1 \\
 \mathbf{I}_i &= 2 \text{ if } \boldsymbol{\mu}_1 < \mathbf{I}_i^* \leq \boldsymbol{\mu}_2 \\
 \mathbf{I}_i &= 3 \text{ if } \boldsymbol{\mu}_2 < \mathbf{I}_i^* \leq \boldsymbol{\mu}_3 \\
 \mathbf{I}_i &= 4 \text{ if } \boldsymbol{\mu}_3 < \mathbf{I}_i^* \leq \boldsymbol{\mu}_4 \\
 \mathbf{I}_i &= 5 \text{ if } \boldsymbol{\mu}_4 < \mathbf{I}_i^* \leq \boldsymbol{\mu}_5
 \end{aligned} \tag{7}$$

where the numbers from 1 to 5 correspond to levels from strongly disagree to strongly agree, respectively, and  $\boldsymbol{\mu}_0, \boldsymbol{\mu}_1, \boldsymbol{\mu}_2, \boldsymbol{\mu}_3, \boldsymbol{\mu}_4, \boldsymbol{\mu}_5$  are vectors of threshold parameters, with each element of vector  $\boldsymbol{\mu}_0$  being equal to  $-\infty$  and each element of  $\boldsymbol{\mu}_5$  being equal to  $+\infty$ . Hence,  $\boldsymbol{\mu}_1, \boldsymbol{\mu}_2, \boldsymbol{\mu}_3$  and  $\boldsymbol{\mu}_4$  need to be estimated.

To facilitate interpretation, the means of the latent variables are normalized to zero, and to assure identification, their variances are normalized to one (Daly et al. 2012; Raveau, Yanez, and Dios Ortuzar 2012). As a result, all latent variables have the same scale and, therefore, their relative importance can easily be assessed.

### 3.3 Structural component

To estimate the effect of the information script on the unobservable perceptions, we include a structural component in our hybrid choice model, where latent variables  $\mathbf{LV}_i$  are explained by information treatment variable  $S_i$ . This relationship can be described by the following equation

$$\mathbf{LV}_i = S_i \boldsymbol{\Psi} + \xi_i \tag{8}$$

with a vector of coefficients  $\boldsymbol{\Psi}$  to be estimated and error terms  $\xi_i$ .

### 3.4 Model estimation

All components of the hybrid choice model are estimated jointly with the maximum simulated likelihood method. Similarly, the mixed logit model is estimated using this method. It is known that results obtained with the method can be sensitive to the selection of starting values, optimization techniques and convergence criteria (Czajkowski et al. 2017). To make sure our findings are robust, we have estimated various specifications of the models and employed various starting values. As a large number of draws is recommended for lowering the simulation error and increasing the probability of unraveling identification issues (Czajkowski and Budziński 2019), we use 10,000 Sobol draws with a random linear scramble and a random digital shift in the final models shown in the paper. The models are estimated in Matlab using a package for modelling discrete choice experiment data, which is available at <https://github.com/czaj/DCE> under CC BY 4.0 license.

## 4 Results

### 4.1 Mixed logit model

To investigate the effect of the information script on stated preferences before decomposing it into the studied pathways, we estimate the mixed logit model in willingness to pay space (Model I). Results are provided in column “Model I” in Table 3. Coefficients of the non-cost attributes in the part “Means” show the *No Script* sample’s estimated average marginal willingness to pay values per year in euro for an increase in the attributes by one tree per 100 meter or by one percentage point. Respondents in the *No Script* sample are willing to pay on average 29 euros per year for an increased number of street trees in Bremen by one additional tree per 100 meters of street, 23 euros per year for the extension of green areas by one percentage point of the total city area, 2 euros per year for one additional extensive green roof per 100 roofs, and 12 euros per year for one additional intensive green roof per 100 roofs. The status quo coefficient is negative, suggesting that respondents are on average willing to pay 20 euros for implementing one of the two combinations of urban green measures rather than maintaining the status quo, holding all attributes constant. All estimated standard deviations for non-cost parameters are



statistically significant and larger than the estimated means (part “Standard deviations” in Table 3). This indicates substantial preference heterogeneity and justifies the use of the mixed logit framework.

The coefficients in the part “Script interactions” allow us to evaluate the information effect - that is, whether the means in the *Script* sample differ from the means in the *No Script* sample. For the non-cost attributes, the interaction coefficients are statistically significant and positive, except for the interaction with extensive green roofs. That is, respondents who see the information script are willing to pay more for increases in these attributes than those who do not see it. The interaction with the status quo is negative: respondents who see the information script are willing to pay for the implementation of one of the two combinations of urban green measures rather than maintaining the status quo, holding all attributes constant. This difference between the two samples is highly significant (p-value < 0.001). This finding is reflected in the frequency with which respondents chose the status quo alternative. Respondents who do not see the script choose the status quo alternative in 28.1% of choices. Respondents who see the script choose the status quo alternative only in 20.7% of choices. These results are in line with the majority of the literature that finds increased value estimates of the considered good upon provision of additional information (Munro and Hanley 2001; Bateman and Mawby 2004).

#### 4.2 Hybrid choice model

To investigate whether part of the information effect identified in Model I can be attributed to a shift in perceptions of the survey consequentiality and the scenario credibility, we analyse the data with a hybrid choice framework (Model II). The results for the discrete choice component of the model are shown in the last column of Table 3; the results of the measurement equations are reported in Table 4; and the results of the structural equations are provided in Table 5. The bottom part of Table 3 contains in addition the diagnostics statistics for the entire hybrid choice model, jointly for the three components. Note that most diagnostic indicators cannot be directly compared between Model I and Model II because for Model II they are based on an extended set of equations and data.

[TABLE 3 APPROX. HERE]

In the measurement equations (Table 4), one latent variable (LV1) is used to explain responses to the four questions on the credibility of each attribute. All four coefficients are positive and statistically significant. This implies that stronger stated credibility in all questions consistently corresponds to higher values of the latent variable. Thus, we refer to this variable as latent credibility. The second latent variable (LV2) is used to explain responses to the questions on perceived payment and policy consequentiality. The significantly positive coefficient estimates in these measurement equations suggest that stronger stated consequentiality in both questions consistently corresponds to higher values of the latent variable. We refer to this variable as latent consequentiality.

[TABLE 4 APPROX. HERE]

The structural equations (Table 5) estimate the effect of the information script on the latent perception variables. The script has a significantly positive impact on the latent credibility (p-value = 0.02). That is, respondents of the *Script* sample perceive the credibility of the proposed attributes as stronger than respondents in the *No Script* sample. The coefficient of the script effect on the latent consequentiality is also positive, but statistically not significantly different from zero (p-value = 0.31). These findings make the credibility pathway possible as a potential explanation of the information effect on stated preferences, but suggest that the information effect cannot be attributed to a shift in consequentiality perceptions.

[TABLE 5 APPROX. HERE]

Table 3 shows that willingness to pay values and standard deviations in the discrete choice component of Model II are very similar to those obtained in Model I. The interactions of the latent credibility with all non-cost attributes are statistically significantly positive. That is, respondents who perceive the proposed extension in green climate change adaptation measures as more credible are willing to pay more for the extension. One standard deviation change in the latent credibility corresponds to a change from the mean willingness to pay in the *No Script* sample ranging from 1.07 euros for extensive green roofs to 10.35 euros for green areas. The interaction of the latent credibility with the status quo is statistically significantly negative. Respondents who view the extension of the attributes as more credible by one standard deviation in the latent variable are willing to pay 6.24 euros more for one of

the two combinations of green climate change adaptation measures than for the status quo, holding all attributes constant.

The interactions of the latent consequentiality with all non-cost attributes are also statistically significantly positive. That is, respondents who perceive the survey as more consequential are willing to pay more for the extensions of the green climate change adaptation measures. The size of the consequentiality interactions is similar to the credibility interactions. One standard deviation change in the latent consequentiality corresponds to a change from the mean willingness to pay in the *No Script* sample ranging from 0.85 euros for extensive green roofs to 10.05 euros for street trees. The interaction of the latent consequentiality with the status quo is statistically significantly negative. Respondents who perceive the survey as more consequential by one standard deviation in the latent variable are willing to pay 6.55 euros more for one of the two combinations of green climate change adaptation measures than for the status quo, holding all attributes constant.

#### 4.3 Decomposing the information effect

To investigate shifts in perceptions as potential pathways explaining the effect of the information script on stated preferences, we analyze two parts of the pathway separately. First, we find that the information script has no effect on consequentiality perceptions and a positive effect on credibility perceptions. Second, we observe that stronger perceptions of the survey consequentiality and the scenario credibility correspond to larger willingness to pay for the green climate change adaptation measures. These findings indicate that a part of the effect of the information script on willingness to pay may be caused by a shift in credibility perceptions which in turn affect stated preferences.

The comparison of Model I and Model II enables us to investigate the possibility of the perception pathways in the information effect more directly. While the script interactions in Model I capture the full effect of the script on willingness to pay including all pathways, Model II separates the consequentiality and credibility perception pathways from the script interactions, by capturing them in the structural equations and in the latent variable interactions in the discrete choice component. Conse-

quently, the script interactions in the discrete choice component of Model II can be understood as a remainder of the information effect without the perception pathways.

Table 3 shows that the coefficients of the script interactions are smaller in absolute terms for all non-cost parameters in Model II than in Model I. This implies that the difference in willingness to pay between the *Script* and the *No Script* sample for the considered measures decreases when removing the perception pathways part. The information script effect in Model II is between 14% (1.04 euros) smaller for street trees and 28% (0.22 euros) smaller for extensive green roofs compared to Model I. Similarly, the information script effect on the willingness to pay for implementing one of the two combinations of measures rather than maintaining the status quo is by 16% (1.16 euros) smaller in Model II than in Model I. However, we find evidence that these pathways cannot be responsible for a major part of the script effect: the script interactions that remain statistically significantly positive in Model II imply that willingness to pay for some attributes is still larger in the *Script* sample than in the *No Script* sample after separating out the perception pathways.

## 5 Discussion and conclusions

We examine two pathways which can potentially explain the effect of information scripts on stated preferences: perceptions of the survey consequentiality and perceptions of the policy scenario credibility. Information scripts could influence perceived consequentiality and credibility, which in turn may matter for stated preferences. We use a split sample approach in a discrete choice experiment survey concerning preferences for green climate change adaptation measures in the German city of Bremen. While all respondents are provided with necessary information for understanding the valuation scenario, half of the respondents are provided with additional information about the climate adaptation strategy that the measures are part of. We investigate whether and to what extent differences in stated preferences between the two samples can be explained by information-induced shifts in consequentiality and credibility perceptions, using a mixed logit model and a hybrid choice model.

Our results confirm the information effect commonly found in the literature (Munro and Hanley 2001; Hoevenagel and Linden 1993; Bateman and Mawby 2004). Being provided with the additional

information script increases willingness to pay for the green climate adaptation measures. Our data suggests that the script also strengthens the credibility perceptions, while its effect on consequentiality perceptions is small and not statistically significant. We also observe that stronger perceptions of both consequentiality and credibility correspond to larger willingness to pay. These results indicate that a shift in credibility might explain part of the information effect: facing the information script strengthens perceptions of the credibility of the policy change, which in turn is positively related to willingness to pay for the policy change. On the other hand, because the information script does not significantly increase perceptions of the survey consequentiality, this pathway appears unlikely to explain a meaningful portion of information effects.

Comparing the information effect between the mixed logit model and the hybrid choice model enables us to examine the size of the perception pathways more directly. We find that the information effect is between 14% to 28% smaller in the hybrid choice model that separates out the perception pathways. This suggests that part of the information effect could be assigned to the credibility perception pathway. However, we find evidence that the perception pathways is not responsible for a major part of the information effect.

There are some methodological limitations of our research. The hybrid choice approach prevents measurement errors in modelling responses to the questions on credibility and consequentiality perceptions leading to endogeneity, but it does not protect from other causes of endogeneity. First, the elicited preferences might influence the stated perceptions, not the other way around, as we elicit the perceptions after preference elicitation. Recent research has shown that the position of the perception elicitation has an effect on both perceptions and stated preferences (Lloyd-Smith, Adamowicz, and Dupont 2019; Zawojka, Welling, and Sagebiel 2019), which indicates potential endogeneity between the two. Second, there might be an omitted variable that influences both self-reported perceptions and stated preferences (Chorus and Kroesen 2014). In these two cases, the direction of the causality between the unobservable perceptions and stated preferences is not clear which may lead to endogeneity issues (Mariel and Meyerhoff 2016; Walker and Ben-Akiva 2002). Given these concerns, some caution is needed towards the results about the size of the credibility perception pathway. However, potential

endogeneity does not affect our findings that the information script strengthens credibility perceptions and affects stated preferences, because they are based on the randomized exogenous treatment.

Our study proposes a novel framework for analyzing how information affects stated preferences. This gives rise to several potential future directions of research. First, various potential pathways might explain the effect of an information script. We only investigate the pathways via consequentiality and credibility perceptions. Further research could examine other pathways such as knowledge on the good to be valued, attitudes towards the good or policy scenario, perceived demand from the experimenter, cognitive availability and trust in institutions.

Second, previous studies by Hoevenagel and Linden (1993), Ajzen, Brown, and Rosenthal (1996), Czajkowski, Hanley, and LaRiviere (2016) and Yang and Hobbs (2020) show that information effects can depend on how extreme a script is, as well as its style and length. We chose a brief information script that could plausibly affect perceptions of the survey consequentiality, because it emphasized that respondents' decisions concern the implementation of an actual strategy of the city. We also suspected that this kind of script may strengthen the perceived credibility of the policy change because respondents might have found the presented policy more plausible when it was related to the actual strategy. However, designing a script that has an even larger effect on stated preferences could improve the precision of decomposing its effect into several pathways. It would also be valuable to investigate whether the share of the pathways is different for different types of scripts.

Third, previous research shows that the effects of information scripts can also depend on the type of good to be valued. Information effects are larger if the good is unfamiliar or non-use values are important (Bateman and Mawby 2004). Green areas, green roofs and street trees in our study have some non-use value, but may be familiar to most of the respondents. A similar information script might cause a larger information effect in the valuation of a more unfamiliar good, which again would allow a more precise decomposition of the effect into several pathways.

Our results also have practical implications for stated preference surveys. The perceived credibility of the scenario is often overlooked, and there is little advice on how it can be reinforced. Our results show that a brief information script on the policy context of the scenario can strengthen credibility

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perceptions. Stated preference practitioners should incorporate such effective information scripts because a credible survey is desirable for valid value estimates (Johnston et al. 2017). In our study, the information script improved perceived credibility more than perceived consequentiality. This suggests that researchers should focus at least as much on credibility implications as on survey consequentiality when designing information scripts. In addition, they should incorporate follow-up questions on perceived credibility in pretests to assess whether the information provided is sufficient for valid value estimates. Further, our results indicate that strengthening credibility perceptions with information scripts may in turn affect stated preferences. This suggests that when including additional information scripts designed to improve credibility, changes in value estimates are a desirable consequence rather than a sign of bias. However, a significant part of the effect of the script on stated preferences cannot be attributed to the pathways via credibility or consequentiality. This demands caution and additional follow-up questions in pretesting to determine whether the information in the survey affects stated preferences via potentially desirable pathways such as learning or stronger perceptions of credibility and consequentiality, or undesirable pathways such as availability heuristics or experimenter demand.

## Notes

<sup>1</sup>However, opposite findings are also reported. Some studies find no relationship (Broadbent 2012; Oehlmann and Meyerhoff 2017) or observe value estimates to decrease with stronger consequentiality beliefs (Vossler, Doyon, and Rondeau 2012).

<sup>2</sup>The questionnaire was presented to respondents in German. All scripts, questions and responses described in this paper are translated to English by the authors.



## Figures

	Combination A	Combination B	Current state
<b>Street trees</b>	+ 1 tree per 100 meters of a street	+ 2 trees per 100 meters of a street	<b>As today</b>
<b>Green areas</b>	+ 1% of the city area is green spaces	<b>As today</b>	<b>As today</b>
<b>Extensive green roofs</b>	+ 5 out of 100 roofs are extensive green roofs	+ 10 out of 100 roofs are extensive green roofs	<b>As today</b>
<b>Intensive green roofs</b>	<b>As today</b>	+ 2 out of 100 roofs are intensive green roofs	<b>As today</b>
<b>Cost for you per year</b>	€20	€5	€0
<b>Which option do you choose?</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Note: The tasks were originally displayed in German.

Fig. 1 An example choice task

## Tables

**Table 1** Discrete choice experiment attributes and their levels

<b>Attribute</b>	<b>Description</b>	<b>Levels</b>
Street trees	Average number of trees per 100 meters of a street	As today (5 trees) 1 tree more 2 trees more
Green areas	Share of green spaces of the total area of the city	As today (13%) An increase by one percentage point An increase by two percentage points
Extensive green roofs	Share of roofs that are extensively greened (i.e., those with thin substratum)	As today (less than 1 of 100 roofs) An increase by 5 of 100 roofs An increase by 10 of 100 roofs
Intensive green roofs	Share of roofs that are intensively greened (i.e., those with thick substratum)	As today (less than 1 of 100 roofs) An increase by 1 of 100 roofs An increase by 2 of 100 roofs
Cost	Compulsory yearly payment per individual (in Euro)	0, 5, 20, 50, 100, 200, 400

Table 2: Socio-demographic characteristics

<b>Characteristic</b>	<b>No Script</b>	<b>Script</b>
Age	52.3 (15.4)	51.5 (15.7)
<b>Gender</b>		
Female	44.2%	42.2%
Male	55.6%	57.4%
<b>Household size</b>		
1	19.7%	22.7%
2	44.5%	41.7%
3	15.2%	16.8%
4 or more	17.9%	16.2%
<b>Children under 14</b>		
1	9.8%	8.5%
2	6.4%	7.2%
3	1.0%	1.7%
4 or more	0.7%	0.0%
no children under 14	78.1%	78.5%
<b>Household monthly income [EUR]</b>		
less than 1,000	3.4%	3.9%
1,000 - 1,999	14.3%	12.3%
2,000 - 2,999	22.4%	22.4%
3,000 - 3,999	20.1%	21.2%
4,000 - 4,999	11.1%	14.0%
5,000 or more	13.2%	11.8%
<b>Number of respondents</b>	<b>593</b>	<b>585</b>

*Note:* For Age, the table shows means (and standard deviations in parentheses). For Gender, Household size, Children under 14 and Household monthly income, shares of participants are reported. The shares do not sum up to 100 % because of missing observations.

**Table 3** Results of Model I and the mixed-logit component of Model II

	Model I	Model II
Means		
status quo	-20.28 (1.03)***	-20.14 (1.15)***
street trees	29.12 (2.42)***	28.56 (2.85)***
green areas	23.35 (2.88)***	23.82 (3.19)***
extensive green roofs	1.74 (0.42)***	1.82 (0.44)***
intensive green roofs	11.64 (1.95)***	11.89 (2.19)***
cost (per 1000 Euro)	-3.00 (0.06)***	-2.99 (0.06)***
Standard Deviations		
status quo	23.64 (1.16)***	21.48 (1.21)***
street trees	47.82 (2.47)***	45.96 (2.51)***
green areas	52.17 (2.88)***	50.02 (2.55)***
extensive green roofs	3.96 (0.44)***	3.74 (0.44)***
intensive green roofs	22.58 (2.12)***	23.24 (2.62)***
cost (per 1000 Euro)	1.11 (0.07)***	1.07 (0.08)***
Script interactions		
status quo	-7.48 (1.12)***	-6.32 (1.44)***
street trees	7.47 (3.12)**	6.43 (3.56)*
green areas	6.57 (3.71)*	5.41 (4.02)
extensive green roofs	0.78 (0.48)	0.56 (0.53)
intensive green roofs	4.51 (2.30)*	3.67 (2.87)
cost (per 1000 Euro)	0.10 (0.07)	0.09 (0.08)
Latent credibility interactions		
status quo		-6.24 (0.82)***
street trees		8.55 (2.03)***
green areas		10.35 (2.44)***
extensive green roofs		1.07 (0.30)***
intensive green roofs		4.40 (1.68)***
cost (per 1000 Euro)		0.10 (0.04)**
Latent consequentiality interactions		
status quo		-6.55 (0.86)***
street trees		10.05 (2.32)***
green areas		6.11 (2.59)**
extensive green roofs		0.85 (0.34)**
intensive green roofs		4.79 (1.77)***
cost (per 1000 Euro)		0.22 (0.05)***
Log-likelihood at convergence	-7854.09	-17255.82
Log-likelihood at constant(s) only	-11442.92	-21410.24
McFadden's pseudo-R <sup>2</sup>	0.31	0.19
Ben-Akiva-Lerman's pseudo-R <sup>2</sup>	0.49	0.49
AIC/n	1.49	3.27
BIC/n	1.51	3.32
Number of observations (n)	10602	10602
Number of respondents	1178	1178
Number of parameters	33	77

Notes: \*\*\*, \*\*, and \* indicate 1%, 5%, and 10% significance levels, respectively. Standard errors are given in brackets. Models are estimated with 10,000 Sobol draws with random linear scramble and random digital shift.

**Table 4** Model II - measurement equations (ordered probit)

	credibility				consequentiality	
	trees	extensive	intensive	green areas	payment	policy
LV1	0.47 (0.04) <sup>***</sup>	0.41 (0.04) <sup>***</sup>	1.41 (0.13) <sup>***</sup>	1.40 (0.13) <sup>***</sup>		
LV2					0.79 (0.13) <sup>***</sup>	1.14 (0.25) <sup>***</sup>
Cutoff 1	-2.03 (0.10) <sup>***</sup>	-1.62 (0.07) <sup>***</sup>	-1.71 (0.12) <sup>***</sup>	-2.32 (0.15) <sup>***</sup>	-1.42 (0.11) <sup>***</sup>	-2.00 (0.26) <sup>***</sup>
Cutoff 2	-0.73 (0.03) <sup>***</sup>	-0.60 (0.05) <sup>***</sup>	0.35 (0.05) <sup>***</sup>	-0.22 (0.05) <sup>***</sup>	0.20 (0.16)	-0.43 (0.06) <sup>***</sup>
Cutoff 3	-0.29 (0.04) <sup>***</sup>	-0.00 (0.05)	1.52 (0.05) <sup>***</sup>	0.84 (0.11) <sup>***</sup>	0.97 (0.24) <sup>***</sup>	0.33 (0.06) <sup>***</sup>
Cutoff 4	1.30 (0.04) <sup>***</sup>	1.55 (0.12) <sup>***</sup>	3.21 (0.13) <sup>***</sup>	2.70 (0.11) <sup>***</sup>	2.31 (0.36) <sup>***</sup>	1.81 (0.07) <sup>***</sup>

Notes: \*\*\*, \*\*, and \* indicate 1%, 5%, and 10% significance levels, respectively. Standard errors are given in brackets. WTP coefficients take into account scaling of the cost variable and thus are denoted in one euro units. Models are estimated with 10,000 Sobol draws with random linear scramble and random digital shift.

**Table 5** Model II - structural equations

	latent credibility	latent consequentiality
information script	0.08 (0.04) <sup>**</sup>	0.04 (0.04)

Notes: \*\*\*, \*\*, and \* indicate 1%, 5%, and 10% significance levels, respectively. Standard errors are given in brackets. Models are estimated with 10,000 Sobol draws with random linear scramble and random digital shift.

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