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An evaluation of attribute anchoring bias in a choice experimental setting

Marjolein J.W. Harmsen - van Hout[1,*], Gaurav S. Ghosh[2], Reinhard Madlener[1]

April 2013

Abstract

We investigate consumer valuations of technical, home-related energy-saving measures (ESMs) and their attributes through a choice experiment. Unlike previous literature we expect heuristic decision-making, as decisions about ESMs are complex. Specifically, in our experimental design we focus on the effects of attribute anchoring through inclusion of an innovative element. We investigate anchoring-and-adjustment (A&A) in a choice-experimental framework, expecting it on attributes. Our question is: does A&A lead to a correct elicitation of the overall valuation or are adjustments insufficient, leading to attribute anchoring bias? To evaluate this, our participants can read attribute information only after clicking on covering buttons. Clicking data reveal what information they use in what order, which provides objective perceived ESM-attribute importance measures to be included as control variables in the estimations. For the experiment we perform a representative online survey among 1084 German residents. Mixed logit analysis cannot show that ESM valuations are affected by attribute anchoring bias, which indicates accuracy of our estimations, and through inference of those in other choice experiments. We also report statistics on ESM-attribute valuations differentiated by e.g. demographics, which is relevant for suppliers and policy-makers alike.

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1 Introduction

We use a large-scale online choice experiment to analyze consumer valuations of technical energy-saving measures (ESMs) for the home in the German energy consumption market. Technical ESMs include home retrofits like energy-saving light bulbs, triple-glazed windows and wall or roof insulation. In the choice experiment respondents value certain attributes or characteristics of such ESMs including their ease-of-use and environmental friendliness. As discussed in this paper, these valuations provide quantitative estimates of consumer preferences for energy savings and thus have a practical relevance from both business planning and public policy perspectives. For example, if the results of this choice experiment indicate that energy consumers have a low willingness to pay for environmentally friendly products, but a high willingness to pay for products with expert recommendations, then one may infer that advertising strategies focusing purely on green marketing strategies will tend to be less effective.

The findings of our choice experiment as presented in this paper contribute to the academic literature on choice experiments, marketing and environmental economics, as well as provide insights for practice. Apart from results on diverse consumers' preference orderings of the various ESM attributes tested in our experiment, we find that the average German energy consumer is not susceptible to an attribute anchoring bias when valuing ESM attributes. An attribute anchoring bias may emerge in choice experiments because of heuristic decision-making on the part of the survey respondent.

Consumer preferences for technical, home-related ESMs have recently been investigated in a number of studies through conjoint choice analysis (e.g., Achtnicht, 2011; Achtnicht and Madlener, 2012; Banfi et al., 2008). These studies assumed rational decision-making, which is not always a tenable assumption in a complex decision-making environment where a number of qualitative attributes are implicitly compared. This is because rational decision-making requires evaluation of all available information, which may place too high a cognitive burden upon the decision-maker when the decision environment is complex and multi-faceted. When the cognitive burden is too high then the decision-maker resorts to a heuristic decision-making process, which may insert a bias into the outcome of the process (cf. Harmsen – van Hout et al., 2010). As will be shown, the ESM decision is made in a complex environment, because of which we expect heuristic decision-making. In this study we focus on attribute anchoring bias, which may result from a particular type of heuristic decision-making process known in the literature as anchoring-and-adjustment (A&A).

With A&A (Tversky and Kahneman, 1974), a valuation task starts at some anchor, providing an initial valuation, after which sequential adjustment happens based on further information, providing

the final valuation. Adjustments are typically insufficient, which leads to a bias towards the anchor (e.g., Epley et al., 2004, concerning own perspective as anchor in perspective-taking; Englich et al., 2006, dealing with irrelevant values as anchors in sentencing decisions; Yadav, 1994, on important items as anchors in consumer bundle valuations; Van der Pligt et al., 1998, regarding irrelevant framing aspects as anchors in understanding and valuing environmental issues).

Our study is the first that investigates A&A in a conjoint choice framework, where we expect important attributes to act as anchors in consumer's overall evaluation. Lopes (1982) extensively demonstrated that A&A takes place in the comparable environment of impression formation, namely with the most important personality traits as anchors. The research question in this paper consists of two parts. First, we investigate the contribution of the different ESM attributes to the final valuation of an ESM. This investigation also allows us to identify the anchor, i.e. the most important attribute, the keystone of the overall valuation of an ESM. Next, we investigate whether the overall ESM valuation is susceptible to an attribute anchoring bias. If such a bias were to exist, then the overall valuation would be inordinately affected by the anchor and insufficiently by the other attributes. In other words, the consumer would focus too much on the anchor when valuing an ESM.

The remainder of this paper is structured as follows. In Section 2, our choice-experimental methodology is explained focusing on an innovative element in the design to test for an attribute anchoring bias. Section 3 provides the econometric analysis of the data from the choice experiment. The data were analyzed using mixed logit regressions. The results indicate the relative values of the ESM attributes for different consumer types and also test the attribute anchoring bias. In Section 4, we discuss implications and avenues for further research.

2 Methodology

The design of our choice experiment contains two novel elements. First, we use abstract names (ESM A, ESM B) rather than specific ESMs like in the previous literature. As a result, our findings are not restricted to specific ESMs. Consequently, the imputed consumer preferences and valuations cannot be ascribed to unknown positive or negative associations that consumers might have with certain ESMs (cf. Achtnicht, 2011, p.2197).

The second design element was added to specifically allow for the testing of the attribute anchoring bias. During a given choice task, the survey participants can read information on a given attribute only after clicking on covering buttons. The resulting clicking data allow us to examine the attribute information that participants access and in what order. This information, in turn, provides objective measures of perceived attribute importance, which can then be used as control variables in

the econometric analysis. This will allow us to determine whether the valuation of a given ESM attribute is affected by an attribute anchoring bias and to what extent. This is an experimental design element that has not been used to date when examining either ESMs or attribute anchoring.

The choice experiment was executed as follows. First, all components of the experiment, from the basic research idea, through design elements, to the final structure were extensively tested through pre-tests and discussions with experts and colleagues. The experiment was finally implemented online (in German) in cooperation with an experienced market research firm. The survey was conducted in April 2012.

We conducted a representative online survey among 1084 German residents stratified on age and sex, containing conjoint choice screens like the one illustrated in Table 1. Five ESM attributes where considered for the purpose of the choice experiment: user effort, energy savings, expert recommendation, home comfort, and annualized costs. The attributes were chosen on the basis of qualitative interviews with residential energy consumers in Aachen, Germany, and feedback from experts and colleagues on a larger set of potential ESM attributes. The larger set of ESM attributes included those investigated by Poortinga et al. (2003). Each survey respondent filled out eight choice screens and a brief questionnaire on demographic characteristics, choice strategies, status quo, etc.

Table 1: Illustration of a choice screen

Choice situation x	**ESM A**	**ESM B**	
User effort	Very much	Very little	
Savings	1%	90%	
Expert recommendation	No	Yes	
Home comfort	Very low	Very high	
Yearly costs	€1000	€1	
Your choice	A	B	Neither A nor B

Per respondent, our data thus consist of eight choices among ESMs with varied attributes, 15 background items, and clicking disclosure of which attribute information was read during the

experiment and in what order. The experimental design was D-optimal and the order in which the attributes were listed to respondents was randomized. Hence, for example, on some choice screens, “user effort” would be the first attribute listed, on some others it would be the second, on some others the third, and so on.

In the real experiment, less extreme attribute values were used than in the example in Table 1 and the covering buttons above the attribute information were not transparent. Complete instructions in German including a table with descriptions of the attributes and their values are available on request; see also Madlener et al. (2013) for more details.

We used a mixed or random parameters logit regression analysis to ascertain whether the sampled German energy consumers are on average affected by an attribute anchoring bias. This is relevant for further research because common practice so far assumes rational decision-making. We also report on preference ordering of ESM attributes by different consumer types and provide reasons for this ordering. Specifically, we consider whether it is a consequence of 'true' valuations or because these consumers did not adjust sufficiently in the A&A process. These results are relevant for suppliers and policy-makers alike because they may indicate a differentiated approach for evaluating and communicating with consumer groups. The regression analysis was conducted using maximum likelihood estimations with the software NLOGIT 4.0 (Econometric Software, Inc.) and was implemented through 1000 Halton draws in the Monte Carlo simulations.

3 Results

3.1 Data cleaning

As discussed earlier, our innovative clicking procedure was implemented to facilitate identification and estimation of the attribute anchoring bias. However, this procedure had an additional benefit. It turned out to be a method for data cleaning and elimination of noisy observations where the respondent appeared to randomly make her decision. Through the clicking procedure we determined that a large part of the respondents (306 out of 1084) made at least one choice without clicking on *any* of the buttons covering the attribute information. These choices were thus made randomly and would only add noise to our estimates and inferences. By removing these observations we were able to improve the efficiency of our estimates.

We tested whether there were any systematic patterns in clicking behavior when respondents chose without reviewing any attribute information by comparing the regression results for three data sets:

(i) all data,

(ii) the data excluding the choices where no attribute information was accessed, and

(iii) the data excluding the respondents who did not access any attribute information for at least one of their choices.

From the results, we can conclude that clicking without review of attribute information led to a non-systematic or random pollution of the data set, as all main effects and coefficient estimates remain about the same. Nevertheless, we only use the most restricted data (iii) in the following analysis. This minimizes the behavior of systematically choosing ESM A (in fact this behavior was completely ruled out) and systematically avoiding to choose neither A nor B (note that some of this behavior remains, as will be shown below).

3.2 Baseline regression

Table 2 contains the first set of estimation results. The listed variables are interpreted as follows: ”no choice“ indicates that the survey respondent chose the option ”Neither A nor B“ in the choice screen. The other five variables are the various attributes of the ESMs: user effort (“effort”), expert recommendation (“expert”), home comfort (“comfort”), yearly costs (“costs”), and energy savings (“savings”).

Table 2: Regression results for baseline regression

Variable	Standardized coefficient	p-value	Standard dev. distribution[3]	p-value
no choice	-8.950	0.0000	19.282	0.0000
effort	-13.136	0.0000	11.308	0.0000
expert	13.026	0.0000	6.571	0.0000
comfort	16.028	0.0000	10.625	0.0000
costs	-17.034	0.0000	16.015	0.0000
savings	17.751	0.0000	11.106	0.0000
AIC: 1.53599 BIC: 1.54897				

As can be seen in Table 2, respondents have a general tendency to avoid the no-choice option and thus to choose one of the two given options. Furthermore, as intuition predicts, people favor low

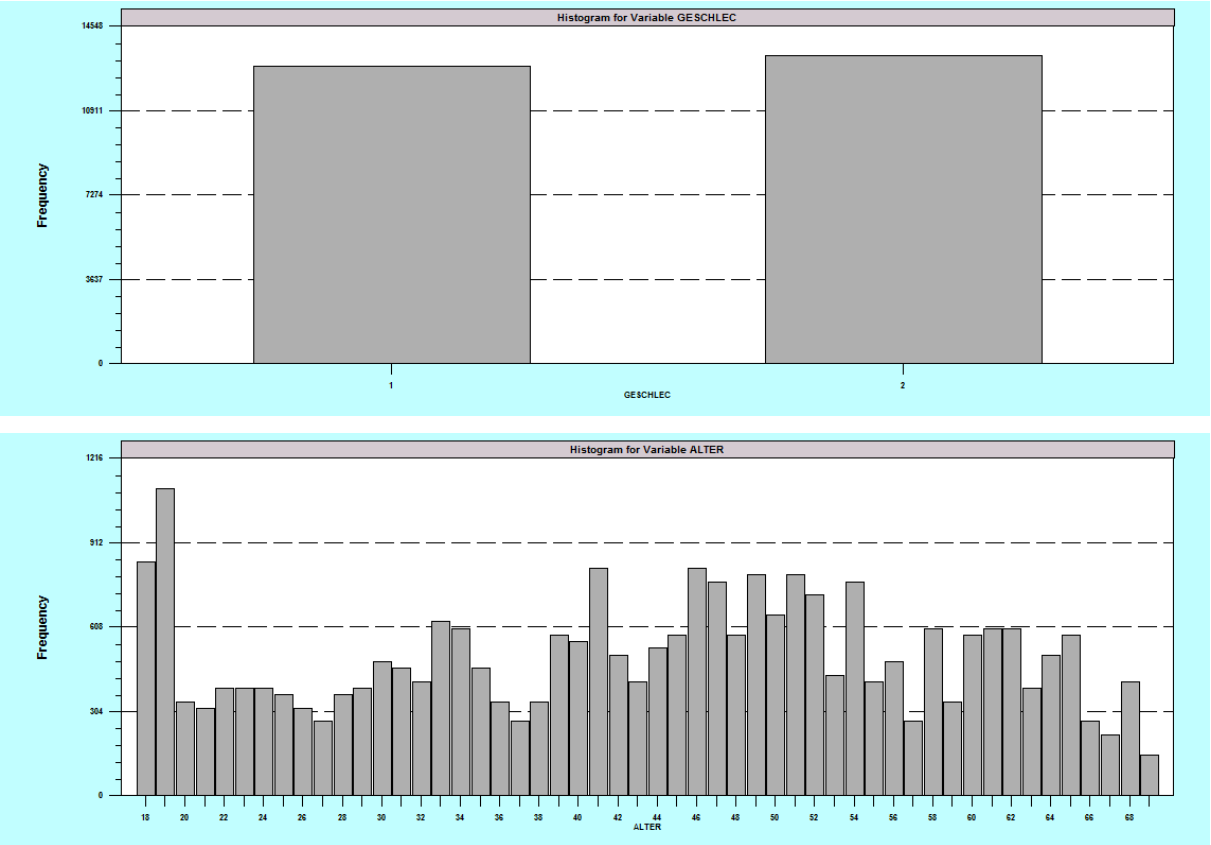
[3] This is the distribution of the random parameters, reflecting heterogeneity among respondents.

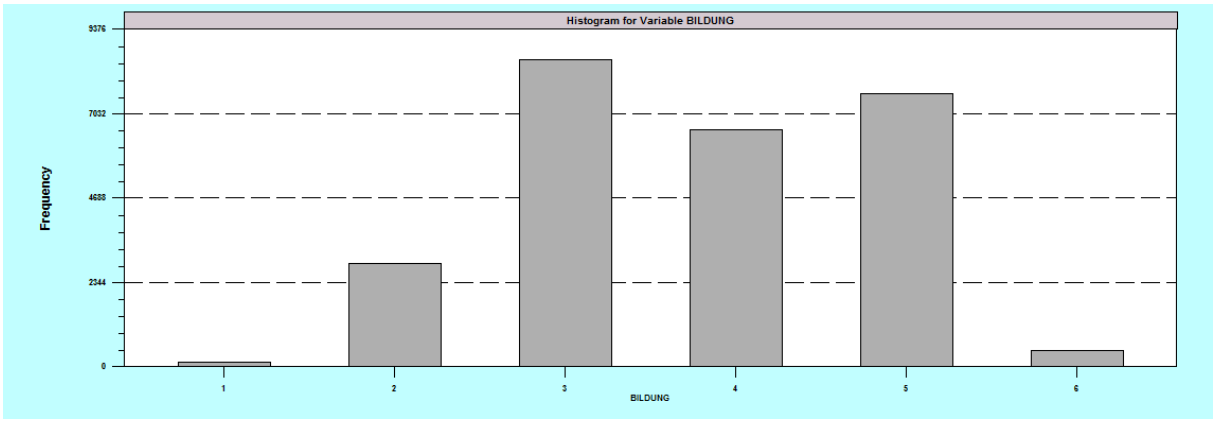
effort and costs as well as an expert recommendation and high comfort and energy savings. On average, energy savings are valued highest, followed by the variables costs, comfort, effort, and expert, consecutively.

3.3 Demographics

Since the baseline regression indicates significant estimated standard deviations of the parameter distributions, we investigated in how far this heterogeneity among consumers can be explained by demographic characteristics. Figure 1 consists of histograms of demographic variables of our (complete) sample.

Figure 1: Histograms for demographic variables

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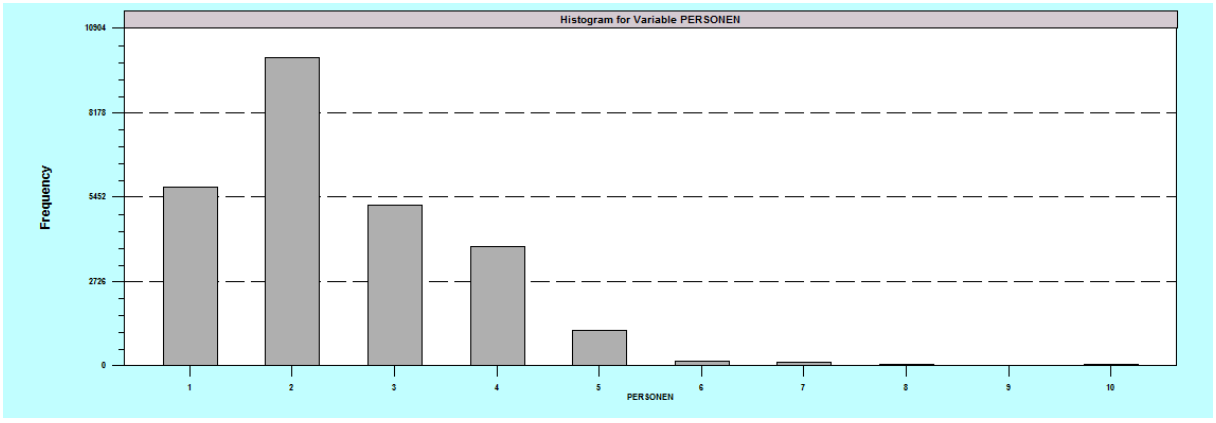
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9
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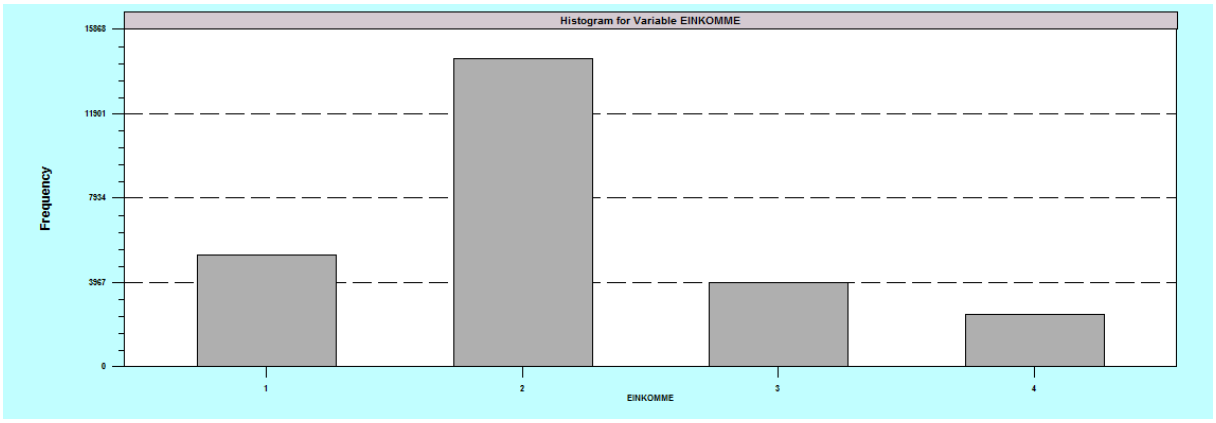
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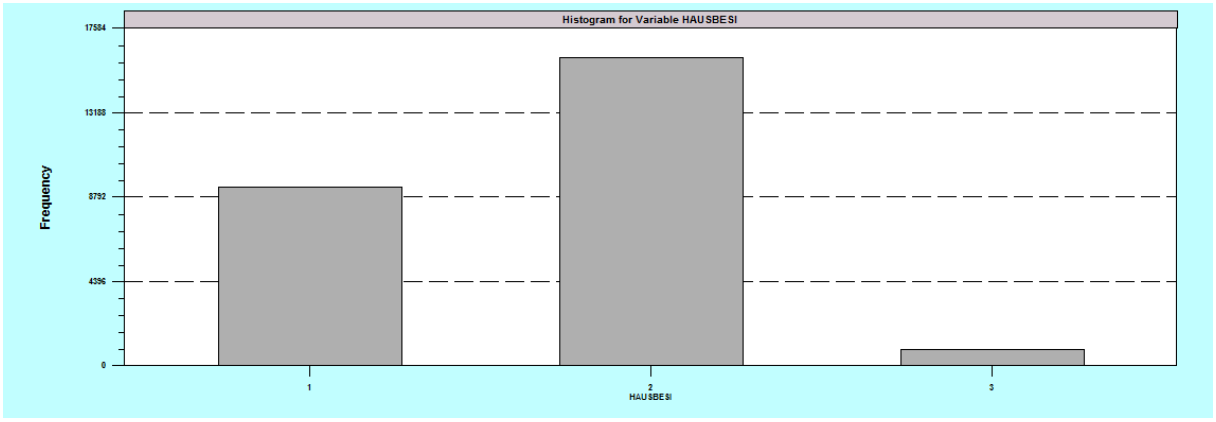
EINKOMME


Histogram for Variable HAUSBESI
Frequency
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2
3
HAUSBESI

Variables were encoded in German, but may be interpreted as follows: "GESCHLEC" is gender (1 = male, 2 = female); "ALTER" is age; "BILDUNG" is education (1 = no graduation, 2 = graduation at “Hauptschule”, 3 = graduation at “Realschule”, 4 = “Abitur”, 5 = graduation at “Hochschule”, 6 = not specified)[4]; "PERSONEN" is household size (7 = not specified); "EINKOMME" is income (1 = below average, 2 = average, 3 = above average, 4 = not specified); and "HAUSBESI" is ownership (1 = house owner, 2 = house renter, 3 = not specified).

From Figure 1, the following inferences can be made. First, the sample is fairly equally distributed among males and females, with a slight preponderance of females. Second, the sample is fairly evenly distributed by age. Third, the significant majority has at least completed their Realschule, which corresponds to intermediate secondary school. Fourth, the household size of the respondents is small, with a modal value of two. Fifth, most respondents declare that they have average income. Finally, the majority of respondents are renters and not home owners.

Table 3 provides a summary of estimation results for separate regressions in which the mentioned demographic variable (excluding possible “not specified” values) is included to explain heterogeneity in mean; any p-value of heterogeneity in mean lower than 0.1 is given in brackets, which indicates significance of said demographic variable. Full regression results are available from the authors upon request.

Table 3: Effects of demographic variables on baseline regression results

Variable	Effects
gender	Females have a weaker tendency to avoid the no-choice option (0.0694) and attach more value to expert recommendation (0.0031) than males
age	The older people are, the stronger their tendency to avoid the no-choice option (0.0035) and the less value they attach to effort (0.0753), expert recommendation (0.0192), and costs (0.0003)
education	The more highly educated people are, the lower their tendency to avoid the no-choice option (0.0044) and the more value they attach to effort (0.0023), expert recommendation (0.0416), and costs (0.0183)
household size	There is no difference between valuations of differently sized households

[4] The German terms can be translated as follows: Hauptschule → lower secondary school; Realschule → intermediate secondary school; Abitur → graduation at higher secondary school (“Gymnasium”); Hochschule → university.

income	The higher income people have, the less value they attach to costs (0.0032)
ownership	House owners attach less value to costs (0.0056) than house renters

3.4 Attribute anchoring bias

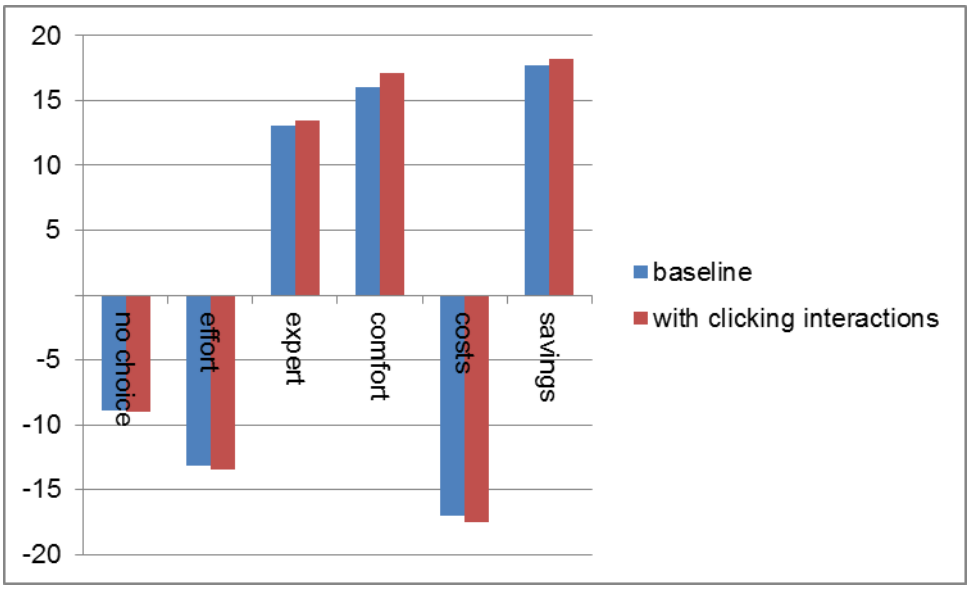
In order to find attribute anchoring bias in consumer evaluations, we repeat the baseline regression, but now replace each attribute by an interaction of the attribute with a variable "click (*)" reflecting the average relative clicking frequency on this attribute for the respective respondent to correct for real attribute importance (in line with e.g. Balcombe et al., 2012, who included interactions with stated attribute importance rankings). The results are given in Table 4.

Table 4: Regression results with clicking interactions, reflecting real attribute importance

Variable	Standardized coefficient	p-value	Standard dev. distribution	p-value
no choice	-9.015	0.0000	19.348	0.0000
effort * click (effort)	-13.452	0.0000	11.094	0.0000
expert * click (expert)	13.436	0.0000	5.686	0.0000
comfort * click (comfort)	17.077	0.0000	9.057	0.0000
costs * click (costs)	-17.559	0.0000	15.631	0.0000
savings * click (savings)	18.217	0.0000	10.660	0.0000
AIC: 1.49588 BIC: 1.50887				

As can be seen in Table 4, the estimated coefficients and their significance hardly deviate from those of the baseline regression (Table 2). This is visualized in Figure 2. From this we conclude that attribute anchoring bias does not play a noteworthy role here: baseline estimation results do reflect real valuations of ESM consumers. This result is robust for other definitions of the clicking variable: relative clicking frequency on this attribute for the respective choice screen (rather than respondent), or first clicking or first or second clicking (rather than average relative clicking frequency) on this attribute for the respective choice screen.

Figure 2: Comparison of estimated coefficients between baseline regression (Table 2) and regression with clicking interactions (Table 4) to evaluate attribute anchoring bias



However, if we estimate separate regressions where one of the demographic variables as illustrated in Figure 1 is included to explain heterogeneity in mean, we do find support for noteworthy attribute anchoring bias (only) when focusing on the demographic variable *age* (the respective p-values of heterogeneity in mean are given in brackets): more specifically, we notice that, when correcting for clicking, the older people are, the less value they also attach to comfort (0.0448) and savings (0.0781), whereas in the baseline regression this is not the case (0.1363 and 0.3366, respectively). This may be due to a lack of adjustment in the evaluation process of older respondents.

3.5 Sensitivity analysis

We performed a number of supplementary regressions to test the sensitivity of our results to elements of our experimental design and regression framework. First, the regressions were rerun under different methods for coding the costs variable (costs were effects-coded in the results presented above). Second, different specifications of the random parameter distributions were used (normality was assumed in the results above). The results described above were found to be robust to both coding effects and to different specifications of the random parameter distributions. Sensitivity analysis also indicates that attribute order effects were not present, where attribute order refers to the order in which the attributes were listed on the choice screens.

We also check for learning effects by repeating the baseline regression, but this time including interactions with a dummy variable "experience" that equals zero for the first four choice screens of the respective respondent, and one for the last four screens. The results are reported in Table 5.

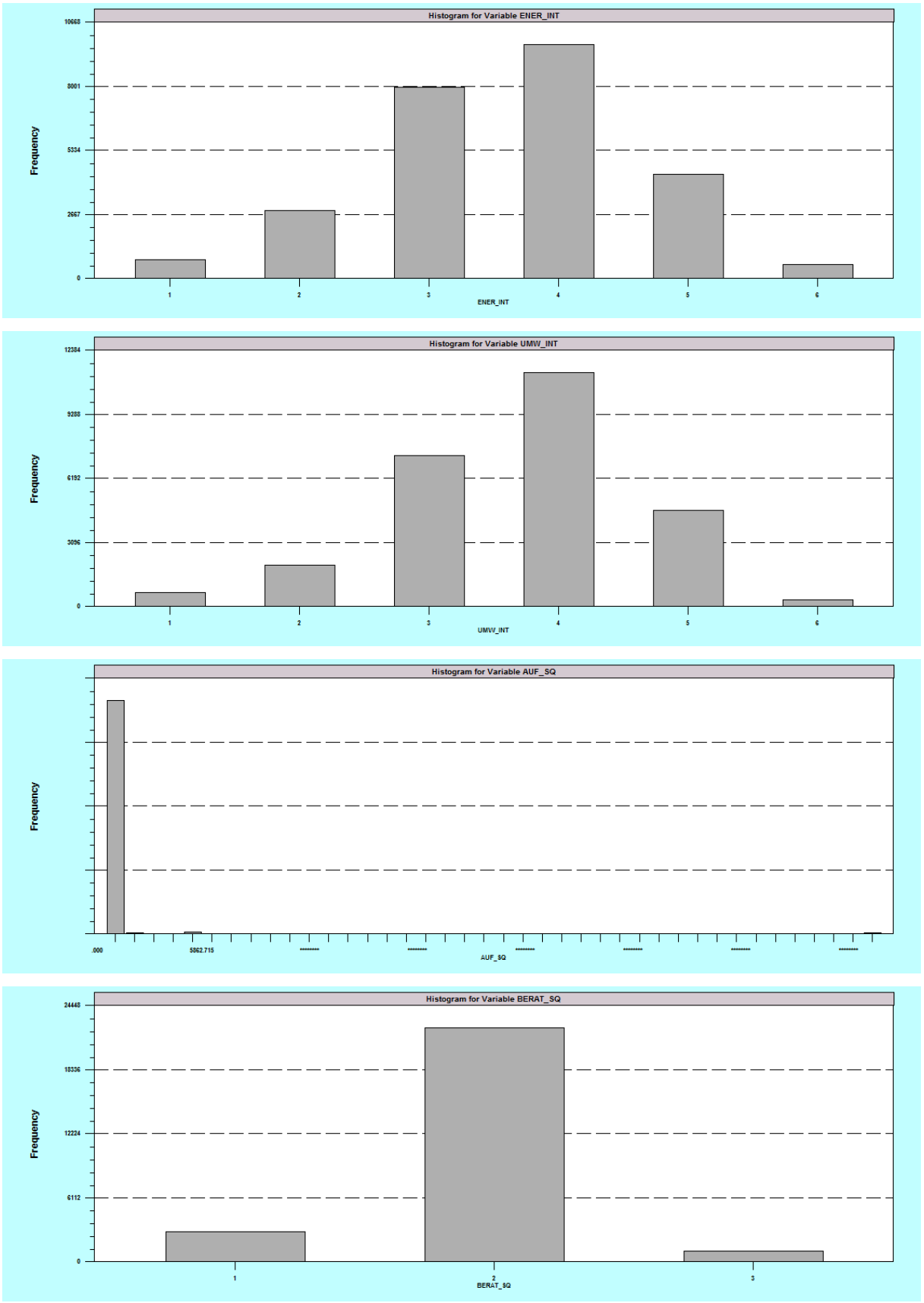
As can be seen in Table 5, over the course of the choice experiment, respondents decrease their systematic tendency to avoid the no-choice option. Experienced respondents also value costs and energy savings higher than beginners and this effect is stronger for costs: costs are valued second-highest by beginners and highest by experienced participants. However, it should be kept in mind that overall, costs are valued second-highest (cf. Table 2), which implies that the experience effect is not very strong.

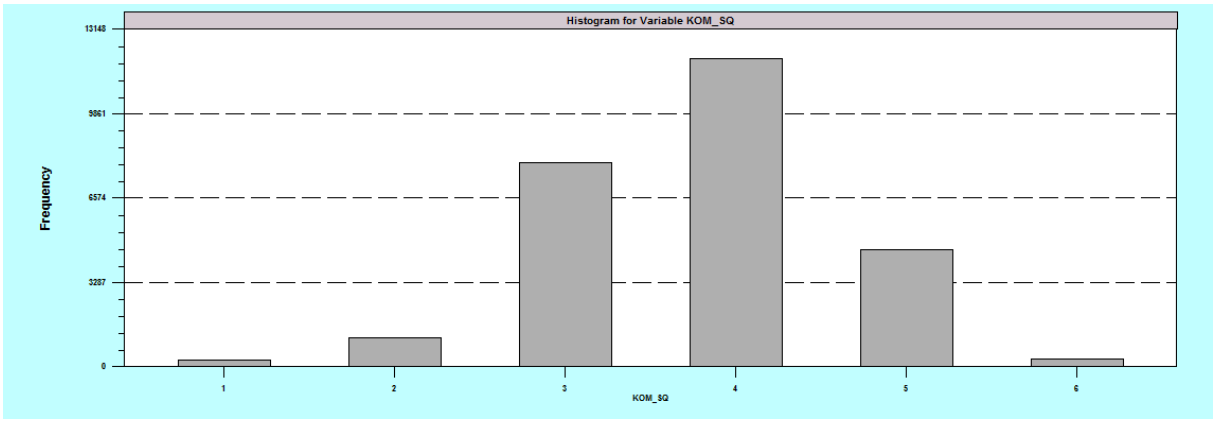
Table 5: Regression results with experience interactions, reflecting learning

Variable	Standardized coefficient	p-value	Standard dev. distribution	p-value
no choice	-9.486	0.0000	17.774	0.0000
effort	-10.254	0.0000	9.947	0.0000
expert	10.265	0.0000	4.986	0.0000
comfort	12.366	0.0000	9.868	0.0000
costs	-13.061	0.0000	13.732	0.0000
savings	13.743	0.0000	9.451	0.0000
experience * no choice	6.100	0.0000	1.548	0.1216
experience * effort	-0.855	0.3927	4.236	0.0000
experience * expert	0.191	0.8486	3.689	0.0002
experience * comfort	1.416	0.1569	2.171	0.0299
experience * costs	-3.826	0.0001	2.251	0.0244
experience * savings	2.149	0.0316	3.788	0.0002
AIC: 1.53141 BIC: 1.55739				

Our dataset also contains many other background variables, for which we can in principle perform similar analyses. For some of these, descriptive statistics (histograms) for our complete sample are given in Figure 3.

Figure 3: Histograms for several background variables

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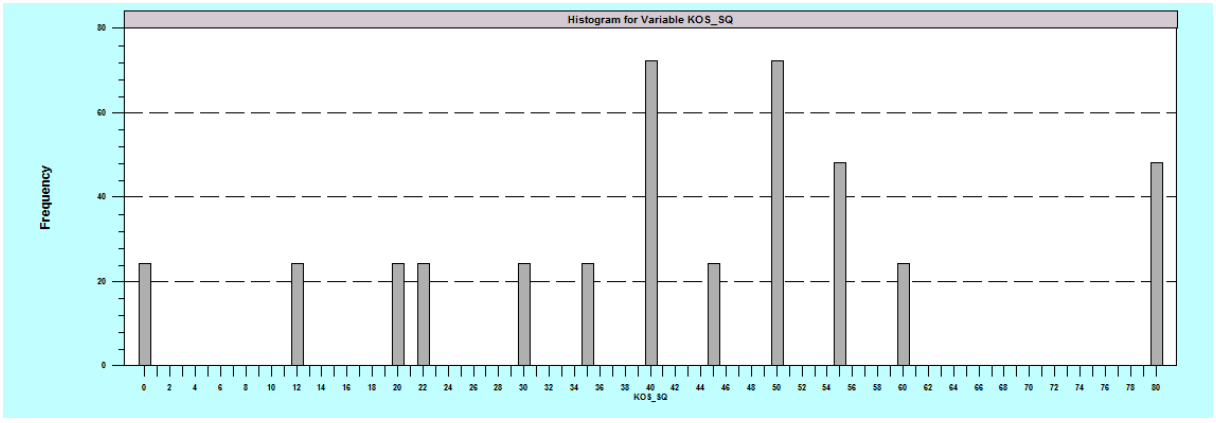
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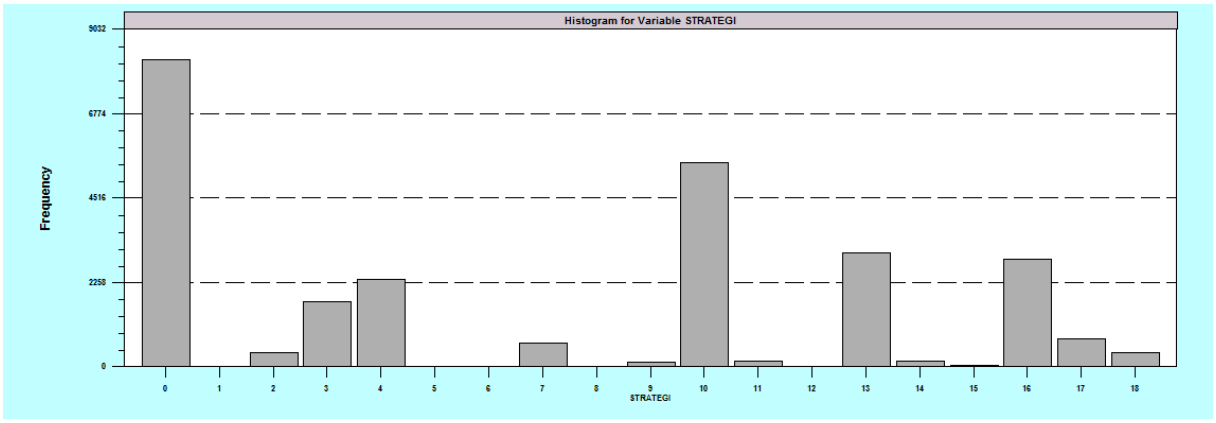
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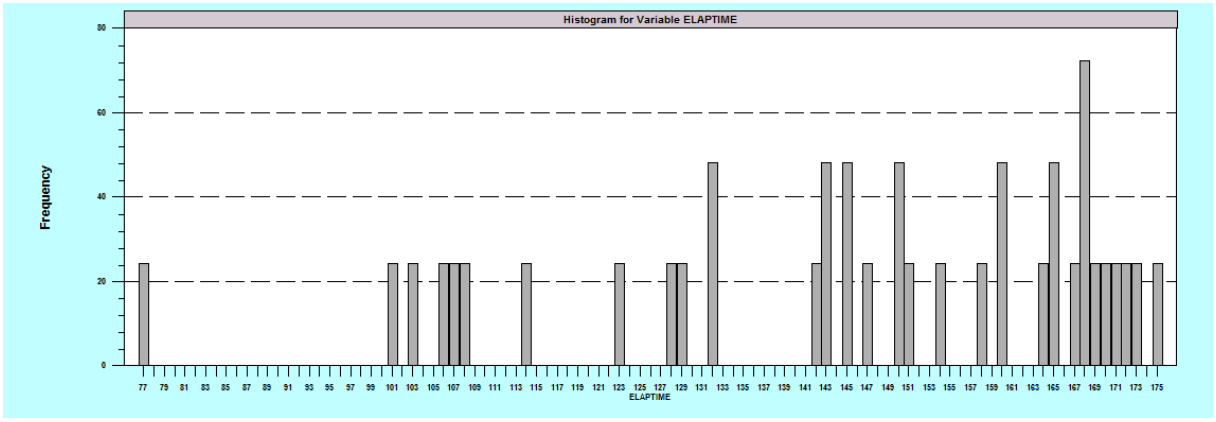
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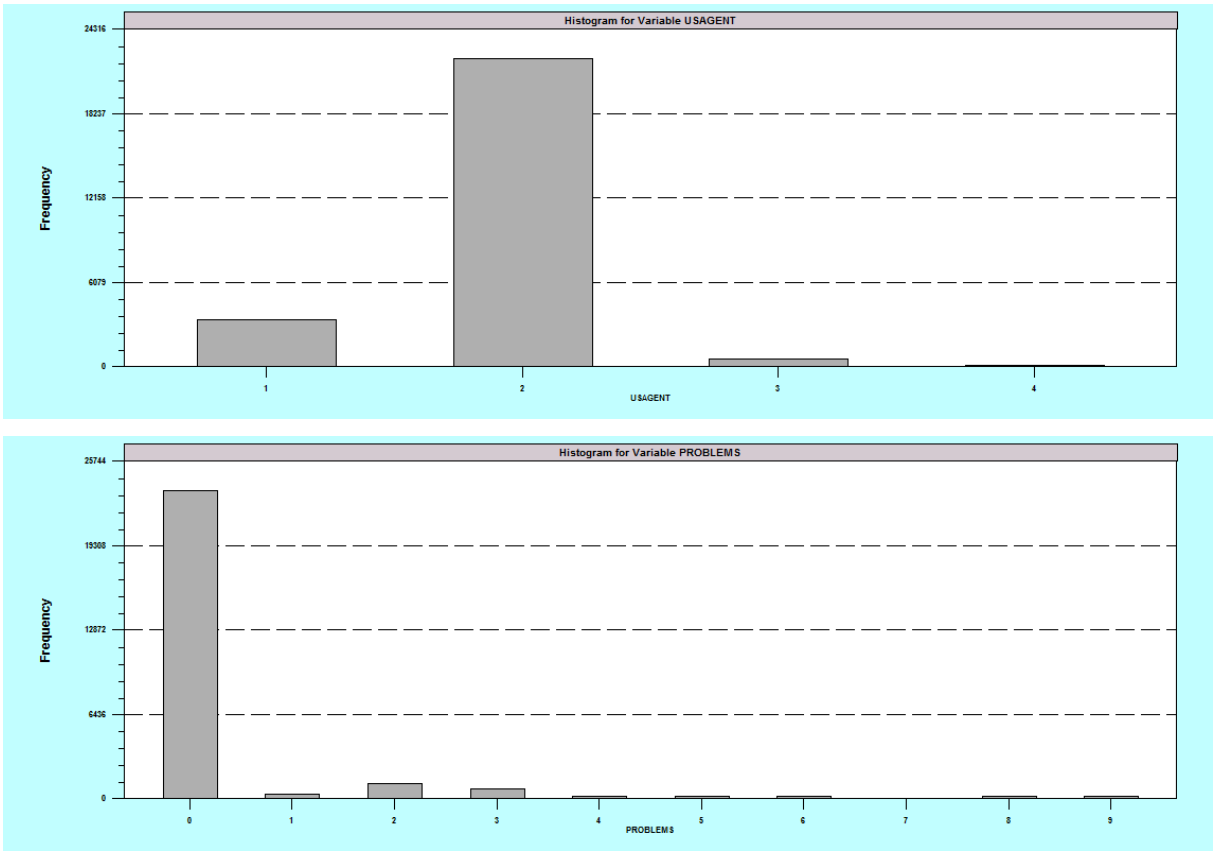

Variables coding in order of appearance may be interpreted as follows: “ENER_INT” is interest in energy (1 = not at all, …, 5 = very much, 6 = not specified); “UMW_INT” is interest in the environment (1 = not at all, …, 5 = very much, 6 = not specified); “AUF_SQ” is status quo effort for energy use (in minutes per week); “BERAT_SQ” is status quo expert consulted (1 = yes, 2 = no, 3 = not specified); “KOM_SQ” is status quo home comfort (1 = very bad, …, 5 = very good, 6 = not specified); “KOS_SQ” is status quo yearly energy costs (in Euros); “STRATEGI” is choice strategy (0 = not specified, {1, …, 18}: strategy categories, e.g., 10 = savings is important); “ELAPTIME” is time used for the choice experiment in seconds; “USAGENT” is user agent (1 = Mozilla/4.0, 2 = Mozilla/5.0, 3 = Opera/9.8, 4 = Blackberry9700/5.0.0.6561); and “PROBLEMS” is problems reported (0 = none, {1, …, 9}: problem categories, e.g., 2 = with covering buttons). These variables are not discussed any further here.

4 Conclusion

Although this large-scale online choice experiment on consumer preferences for home-related ESMs in Germany was explicitly designed to elicit it, it could not be shown that average consumer preferences are affected by attribute anchoring bias, which provides a foundation of trust for the valuations estimated in this study, but conceivably also for those estimated in any conjoint choice

experiment. Furthermore, the fact that cleaning our dataset from (participants making) uninformed choices did not cause relevant changes to the valuations may be of general comfort to researchers performing choice experiments. Finally, we elaborately reported on which attributes of ESMs are valued highest by what type of consumers and why (cf. attribute anchoring), which is relevant for suppliers and policy-makers alike.

We did find some evidence of an attribute anchoring bias among older respondents. Although it is beyond the scope of this paper to investigate the reasons for this, some speculations can be made. One possibility is that old and young consumers have slightly different decision-making processes, where the old are more likely to resort to the heuristic A&A, while the young are more likely to consider all available data concurrently. A second possibility is that all consumers use the heuristic A&A, but that the attribute anchoring bias only manifests itself in the old since they do not adjust their valuation well enough during the process. All decisions require cognitive effort and it is feasible that the old are either less willing or less able to provide the required cognitive effort and thus place excessive reliance on the anchors when performing the valuation exercise.

Future work could investigate other types of heuristic decision-making that can be expected in choice-experimental settings. For example, Harmsen - van Hout et al. (2013) find that ESM consumers are susceptible to a certain type of framing. Furthermore, Alfnes et al. (2006) show the feasibility of including real incentives in a conjoint choice study on consumer valuations of salmon. However, for practical reasons most conjoint studies are performed without real incentives. It would be possible to find out how critical this is for the results of such a study, say by randomly assigning participants to treatments with and without real incentives in a setting as in Sammer and Wüstenhagen's (2006) conjoint choice study on the influence of eco-labeling on consumer light bulb choice.

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