This way, please: Uncovering the directional effects of attribute translations on decision making

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Abstract

The translation of choice attributes into more meaningful information (e.g., from kWh to costs) is a form of choice architecture that is thought to facilitate decision making by providing decision signposts that activate personally relevant but latent objectives and guide decisions towards options that are most congruent with the activated objectives. Here, we investigated the psychological mechanisms that underlie and drive the directional effects of attribute translations on decision making. Across two choice experiments (total $N = 973$), we provide empirical support for our proposition that attribute translations operate via pre-decisional attention processes. Specifically, we demonstrate that attribute translations focus individuals' attention on choice options that are most congruent with the concerns highlighted by translations, and that this attentional prioritization of alternatives predicts choice. In addition to the cognitive mechanisms underlying attribute translations, we highlight the choice architectural principles that moderate the effectiveness of translations. We show that the directional effects of attribute translations are driven by the information that translations provide rather than by contextual changes in the decision environment. In line with previous research on evaluability, we find the effectiveness of attribute translations to depend on information format, with translations conveying evaluative information having a larger impact on decision making than translations providing numerical information. The present study is among the first to investigate the decision making processes underlying a choice architectural intervention. It provides insights into the mechanisms that drive and facilitate the signpost effect and renders recommendations for the implementation of attribute translations in policy making.

Keywords: choice architecture, attribute translation, process tracing, attention, energy consumption

1 Introduction

Even when stakes are exceptionally high, individuals often do not seem to follow the rules of rationality, which assume that decisions are based on an elaborate computation of the utility of all choice options and the selection of the option that maximizes the received utility. Examples of this supposedly irrational behavior can be found across a variety of domains, be it the failure to invest in a retirement plan, to choose an appropriate health care plan, or to capitalize on the economic and environmental benefits of energy efficiency. One reason for this deviation from rationality is the fact that humans frequently have to make decisions under limited time, information, and computational power, which Simon (1955, 1982) captured under the concept of *bounded rationality*. These limitations make humans highly susceptible to contextual influences, such as the way in which information is presented or structured (Lichtenstein & Slovic, 2006; Payne, Bettman & Johnson, 1992). Individuals, for example, tend to base their decisions almost exclusively on information that is directly available to them, a phenomenon Slovic (1972, p. 9) described as the *concreteness principle*: "[...] a judge or decision maker tends to use only the information that is explicitly displayed in the stimulus object and will use it only in the form in which it is displayed. Information that has to be stored in memory, inferred from the explicit display, or transformed tends to be discounted or ignored."

Despite its sometimes detrimental effects on decision making, individuals' susceptibility to contextual factors should, however, not exclusively be seen as a barrier to optimal decision making. As a growing body of literature on the concept of choice architecture illustrates, it also provides a

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unique opportunity to improve decisions by designing environments that take into account the bounded rationality of the decision maker and facilitate desirable behavior through information, structure, and/or assistance (Camilleri & Larrick, 2015; Johnson et al., 2012; Münscher, Vetter & Scheuerle, 2016; Thaler & Sunstein, 2008). In this paper, we focus on one particular tool of choice architecture that so far has received relatively little attention in the literature, the comprehensible expression or "translation" of attributes into varying aspects that are directly derived from those attributes. Across two choice experiments, we use process tracing methods to provide empirical evidence for the cognitive mechanisms underlying the effects of attribute translations on decision making and identify the choice architectural principles that facilitate these effects.

1.1   Attribute Translations

Attribute translations can be understood as a type of choice architecture intervention that highlights different but highly correlated aspects of an attribute (Ungemach, Camilleri, Johnson, Larrick & Weber, 2018). The energy consumption of electric appliances, commonly expressed in kWh, for example, may be translated into the financial costs of operating the appliance or the associated carbon emissions. While both of these attributes are direct transformations of energy consumption, they address different interests or concerns that consumers may pursue in the purchase of an appliance, with economic interests to save money on the one hand and ecological interests to reduce one's impact on the environment on the other hand. This explicit representation of interests is thought to facilitate decision making as it not only addresses the concreteness principle (Slovic, 1972) and thus supersedes the need for consumers to actively extrapolate the implications and personal relevance of attributes, but also activates latent concerns and objectives that may otherwise be overlooked in the decision process. Similar to signposts, attribute translations thus function as cues in the decision environment that indicate the presence of potentially relevant information and direct the decision towards choice options that align with the concerns and objectives of the decision maker (Ungemach et al., 2018).

The principle of the so-called *signpost effect* was first proposed by Ungemach and colleagues (2018), who in a series of choice experiments demonstrated the effectiveness of attribute translations in guiding individuals towards choices that are in line with their objectives. Specifically, their research showed that environmentally concerned subjects were more likely to choose fuel-efficient cars when fuel economy was expressed in terms of a greenhouse gas rating, and thus a translation that was congruent with their values, rather than the average fuel consumption or annual fuel costs, which did not relate to their environmental concerns. This finding complements earlier research based primarily in the economic literature which found the disclosure of monetary information, such as life cycle costs, to increase consumers' preference for long-term investments like energy efficient technologies (for review see Kaenzig & Wüstenhagen, 2009).

How exactly do decision signposts affect decision making? Ungemach and colleagues (2018) propose that the signpost effect of attribute translations is driven by two mechanisms, the activation of relevant objectives and the provision of direction toward one option or another. They base their proposition on previous research showing that the activation of values and objectives can help individuals make more desirable, i.e., congruent decisions (e.g., Feather, 1995; Hahnel, Ortmann, Korcaj & Spada, 2014; Maio, Pakizeh, Cheung & Rees, 2009; Papies & Hamstra, 2010; Shah & Kruglanski, 2003). What remains largely unclear at this point are the cognitive mechanisms that drive this effect (for some initial research on the topic see van der Laan, Papies, Hooge & Smeets, 2017; Verplanken & Holland, 2002). In this paper, we therefore want to focus specifically on the second component of decision signposts, the provision of direction, and investigate how the translation of attributes affects not only decisions but also the decision making processes underlying them. We argue that the directional properties of attribute translations are based on an attentional process that directs individuals' information acquisition and integration in a way that prioritizes choice options that are most congruent with the concerns highlighted by translations.

1.2   Cognitive Mechanisms

Despite its foundation in a field that traditionally emphasizes the study of human cognition, research on choice architecture has paid comparatively little attention to the cognitive correlates of choice architectural interventions. Recent advances in process tracing research (Schulte-Mecklenbeck, Johnson, et al., 2017), however, have provided valuable insights into the cognitive mechanisms underlying not only decision making in general but also more specifically decision making in the presence of interventions that are based on principles of choice architecture. Using various process tracing methods, including concurrent verbal reporting, eye and mouse tracking as well as psychophysiological and neurological measurements, this research has brought forward strong empirical evidence for the significant role that predecisional information acquisition and integration processes play in decision making and in particular the construction of preferences (e.g., Johnson, Häubl & Keinan, 2007; Krajbich, Armel & Rangel, 2010; Shimojo, Simion, Shimojo & Scheier, 2003; Weber et al., 2007; for an overview of process tracing research in the field of decision science see Schulte-Mecklenbeck, Kühberger & Johnson, 2019).

Among the strongest cognitive determinants of the decision process is visual attention, which across a variety of domains has been found to moderate decision making (Orquin

& Mueller Loose, 2013; Smith & Krajbich, 2018). In contrast to the comprehensive information processing assumed by classical and neoclassical models of decision making, process tracing research has shown that individuals' attention throughout the decision process is characterized by a high degree of selectivity (for reviews see Gigerenzer & Gaissmaier, 2011; Payne et al., 1992; Weber & Johnson, 2009). One of the most robust findings in the literature illustrating this selectivity is the so-called *utility effect*, which refers to individuals' tendency to direct their attention to information with high utility, relevance or importance to the decision (Brosch, Sander, Pourtois & Scherer, 2008; Orquin & Mueller Loose, 2013). Research on the cognitive correlates of loss aversion (Kahneman & Tversky, 1979, 1984), for example, has found that the commonly observed differences in decision weight attached to losses and gains are associated with an attentional bias towards losses relative to gains (Pachur, Schulte-Mecklenbeck, Murphy & Hertwig, 2018). Similarly, research in the field of consumer behavior has found a positive link between individuals' importance ratings of product attributes and their relative attention towards those attributes (e.g., Reisen, Hoffrage & Mast, 2008). The selective allocation of attention described by the utility effect is not restricted to individual attributes, but extends to a general attentional prioritization of choice options that early on in the decision process are identified as superior compared to their alternatives (Montgomery & Svenson, 1989; Willemsen, Böckenholt & Johnson, 2011). Presumably, the interests and concerns of the decision maker have a significant influence on this process as they are likely to define the criteria for superiority and thus the degree to which information is considered in the identification of an initial leader, suggesting an early entry point by which attribute translations may impact the decision process.

In the context of simple choice problems, such as the decision between two products, attention has been demonstrated to have a causal impact on choice outcomes. Specifically, attention towards a given choice option has consistently been shown to increase its likelihood to be chosen (Armel, Beaumel & Rangel, 2008; Krajbich et al., 2010; Lim, O'Doherty & Rangel, 2011; Pachur et al., 2018; Pärnamets et al., 2015). The *attentional drift diffusion model* (aDDM) by Krajbich and colleagues (2010) explains this influence of attention on choice in terms of a modulation of evidence accumulation processes. Based on earlier sequential sampling models, aDDM treats the decision making process as a course of evidence accumulation that determines the relative subjective value of each choice option. Once the accumulated evidence for a choice option is sufficiently strong to pass a decision threshold, a decision in favor of that option is made. Attention is thought to modulate this process by increasing the extent to which evidence is accumulated for an option when it is being looked at relative to when it is not. In other words, the more attention a choice option receives, the more evidence is accumulated for that option. As a result of the increased rate in evidence accumulation, choice options that receive more attention are also more likely to be chosen.

In conclusion, research on pre-decisional information acquisition and integration processes has provided important insights into the role of attention in decision making. These findings can be applied to the study of the cognitive mechanisms underlying the signpost effect of attribute translations. Recall that attribute translations are assumed to activate relevant but latent concerns and objectives. In this article, we argue that this activation of objectives through translations affects early decision making processes by increasing the degree to which concerns related to those objectives are considered in the initial identification of a superior choice option. For example, increasing environmental concerns through the translation of energy consumption into carbon emissions is expected to increase the weight of environmental concerns in the selection of an initial leader. Following research on the utility effect, choice options that are congruent with the objectives activated by translations are thus likely to receive more attention throughout the information acquisition and integration process compared to their alternatives. Due to the resulting advantage in relative evidence accumulation (Krajbich et al., 2010), concern-congruent choice options are consequently more likely to be chosen.

In order to test this proposition, our research applied process tracing methods to a discrete choice paradigm to reveal how purchase decisions, and also the information acquisition processes underlying those decisions, are affected by the presence of attribute translations. To our knowledge, this is the first study to apply such a comprehensive approach and examine the effects of attribute translations on both a behavioral and a cognitive level, providing unique insights into the functioning of this choice architectural intervention.

1.3 Choice Architectural Determinants

In addition to the cognitive mechanisms underlying the signpost effect of attribute translations, the extent to which informational elements, such as the content and format of attribute translations, and contextual elements, such as the number of translations, facilitate this effect is unknown. However, just as signposts on the roadside sometimes fail to direct us towards our destination because they are difficult to detect or comprehend, decision signposts too may differ in their effectiveness in guiding decisions because of the way they present information and/or the environment in which they are placed. This possibility is supported by research showing that even small alterations in the presentation of otherwise similar information can have a substantial impact on judgments and decisions (e.g., Bazerman, Loewenstein & White, 1992; Burson, Larrick & Lynch, 2009; Camilleri & Larrick, 2014; Enax, Krajbich & Weber, 2016; Hardisty, Johnson & Weber, 2010; Hoffrage, Lindsey, Hertwig & Gigeren-

zer, 2000; Hsee, 1998; Keller, Kreuzmair, Leins-Hess & Siegrist, 2014; Levin & Gaeth, 1988; Moore, 1999; Pandelaere, Briers & Lembregts, 2011; Tversky & Kahneman, 1981). According to the *General Evaluability Theory* by Hsee and Zhang (2010), the degree to which information affects decision making is in part determined by its evaluability or the extent to which the objective value of information can be estimated and mapped onto an evaluative scale. Peters and colleagues (2009), for example, showed that adding evaluative categories to numeric information on the quality of health care plans increased the degree to which this information was considered in decision making and ultimately improved the quality of choices.

Given the importance of information presentation in the formation of decisions, we predict a direct link between informational elements of the decision environment and the directional effects of attribute translations on decision making. Specifically, we argue that the extent to which translations are considered in the early differentiation between choice options increases as the evaluability of translations improves. As a result, highly evaluable translations such as ratings are more likely to direct pre-decisional information acquisition and integration processes and subsequent choices than translations with low evaluability such as numeric information on an attribute of which the decision maker has little or no expertise.

Similarly, we argue that contextual components of the decision environment, such as the number of provided attribute translations, moderate the effectiveness of translations to guide decision making. Specifically, we propose that the cognitive and behavioral effects of attribute translations become stronger as the number of translations favoring a single choice option increases. That is, two translations of the same attribute are assumed to have a stronger impact on decision making than one translation. We base this proposition on previous research showing that the mere frequency of favorable and unfavorable attributes per choice option can influence individuals' judgments and decisions (Alba & Marmorstein, 1987; Russo & Dosher, 1983; Zhang, Hsee & Xiao, 2006). Indeed, Ungemach and colleagues (2018) found the signpost effect to be considerably stronger in the presence of two translated attributes as compared to one. The addition of attribute translations should affect early differentiation processes above and beyond the signpost effect of information as it alters the balance of positive and negative attributes between choice options and thus plays into general heuristics in decision making, such as the tallying heuristic, which describes the compensatory decision making strategy to base a choice purely on the number of attributes favoring one choice option compared to its alternatives (Gigerenzer & Gaissmaier, 2011; Gigerenzer & Goldstein, 1996).

1.4   Current Research

In order to test our propositions regarding the directional effects of attribute translations and their link to contextual principles of choice architecture, we conducted two experiments. In Study 1, we established the cognitive and behavioral effects of attribute translations on decision making by investigating information acquisition processes and product choices in the absence and presence of translations. In Study 2, we then identified the choice architectural mechanisms underlying the directional effects of translations by systematically varying the content and number of attribute translations. We focus our research on attribute translations in the energy domain as this has been shown to be a field in which consumers are particularly likely to make suboptimal judgments and decisions (Attari, DeKay, Davidson & Bruine de Bruin, 2010). This is exemplified by the *energy efficiency gap*, consumers' tendency to refrain from investing in energy efficient technologies despite their economic and environmental benefits (Gerarden, Newell & Stavins, 2015; Jaffe & Stavins, 1994).

2   Study 1

The aim of the first study was to conceptually replicate and extend the scarce research on attribute translations by investigating their cognitive and behavioral effects on consumer decision making in the energy domain. In a series of choice problems, we investigated individuals' allocation of attention during the acquisition of product information as well as their subsequent product choices in the absence and presence of translations of energy and water consumption. In line with our proposition that attribute translations direct decision making through the attentional prioritization of concern-congruent choice options, we hypothesized that the provision of translations would increase individuals' relative attention towards energy and water efficient choice options as these were most congruent with the concerns highlighted by translations and thus likely to be identified as an initial leader during the early decision making process. Following previous research on the causal influence of attention on choice (Armel et al., 2008; Krajbich et al., 2010; Lim et al., 2011; Pachur et al., 2018; Pärnamets et al., 2015), we further predicted that the attentional prioritization of energy and water efficient product options would be linked to an increase in ecological product choices.

2.1   Method

Design.   To investigate the effects of attribute translations on decision making, we experimentally manipulated the presence of the factor *attribute translations* (absent [t_1] vs. present [t_2]) within subjects (see Figure A1 of Appendix A).

The dependent variables were subjects' allocation of attention across choice options as measured by the duration of attribute inspections during the acquisition of product information (cognitive effects) as well as their product choices (behavioral effects).

Subjects. A convenience sample of 181 undergraduate students from the University of Geneva (83.98% female, mean age = 22.67 years, $SD = 5.61$) participated in this study in return for partial course credits. Two subjects completed only the first part of the study and were therefore excluded from the analyses, leading to a final sample of 179 individuals.

Materials. *Choice design*. We designed a set of 15 choice problems that required subjects to choose between two washing machine models which were described in terms of their price, energy and water consumption, and popularity (see Table B1 of Appendix B). The levels of these product attributes were largely based on market values in Switzerland and were varied across choice options to force subjects to make trade-offs in their decisions and thus accept less desirable levels of one attribute to obtain a more desirable level of another attribute. For example, subjects who wished to acquire a highly energy and water efficient washing machine had to accept a higher purchase price or lower popularity for this model compared to a less efficient washing machine.

As part of the experimental manipulation at t_2, product descriptions were complemented by three translations of energy and water consumption, namely the estimated costs of operating the appliance, the incurred carbon emissions in kilograms, and a customer rating of environmental friendliness which was expressed on a scale ranging from 1 leaf (poor) to 5 leaves (excellent) (see Table B2 of Appendix B). The translations were chosen to reflect both economic and environmental interests and to provide numerical as well as evaluative information.

Subjects were not informed about the range of possible attribute values prior to the experiment. Similar to many real-life decisions, the relative standing of attributes thus had to be learned from experience. To control for any learning effects, the order of choice problems was randomized. Likewise, the order of product options and product attributes within each choice problem was counterbalanced to minimize potential position effects.

Information acquisition. To assess not only subjects' product choices but also the processes underlying their decisions, choice problems were presented using MouselabWEB (Willemsen & Johnson, 2019), a computer-based process tracing tool that enables researchers to monitor various information acquisition processes, including the allocation of attention across choice options and attributes. Based on the information board approach by Payne (1976), MouselabWEB displays information about the attribute values of different choice options behind boxes. In order to access the information, subjects have to move the cursor of their computer mouse over the respective box, which consequently reveals the information until the cursor is moved outside the box again (see Figure 1 for illustration). MouselabWEB records the duration and frequency of each attribute inspection as well as the sequence of inspections between attributes.

Subjects in our experiment were free to inspect attributes as frequently and for as long as they wanted before indicating their choice. To quantify the amount of attention subjects allocated across choice options, we aggregated the overall duration of acquisitions within each choice option and calculated the relative difference between options in the resulting sum scores (denoted as + for the comparatively more energy and water efficient choice option and − for the comparatively less efficient alternative; see Equation 1).

$$\Delta t_{options} = \frac{t_+ - t_-}{t_{total}} \tag{1}$$

Indices above zero indicated a pre-decisional attentional prioritization of the more energy and water efficient choice option relative to the less efficient option.

Procedure. The study was conducted in two experimental sessions in a computer laboratory at the University of Geneva. Both sessions started with an exercise to familiarize subjects with the MouselabWEB environment and subsequently continued with the experimental task. While the set of choice problems remained the same, the number of product attributes that were provided for each choice option varied across the two experimental sessions. To establish a baseline measurement of subjects' product preferences, the first session (t_1) only presented information about the price, energy and water consumption, and popularity of appliances. In the second session (t_2) 11–17 days later ($M = 13.87$, $SD = 0.83$), these descriptions were then complemented by translations of energy and water consumption. Following the second experimental session, subjects received a full debriefing explaining the aim and research questions of the study.

Data analysis. The effects of attribute translations on subjects' allocation of attention were analyzed by means of a multilevel linear regression model that specified a simple fixed effect for the presence of translations (i.e., experimental session). To account for the repeated measures design of our experiment and possible differences across choice problems, the model further specified random effects for subject and choice problem.[1]

Similarly, the effects of attribute translations on subjects' product choices were analyzed by means of a multilevel logistic regression model that assessed the probability of

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[1]Using the R package lme4 (Bates, Mächler, Bolker & Walker, 2015), the model was specified as: lmer(attention ~ (session | subject) + (1 | problem) + session, data = mydata).
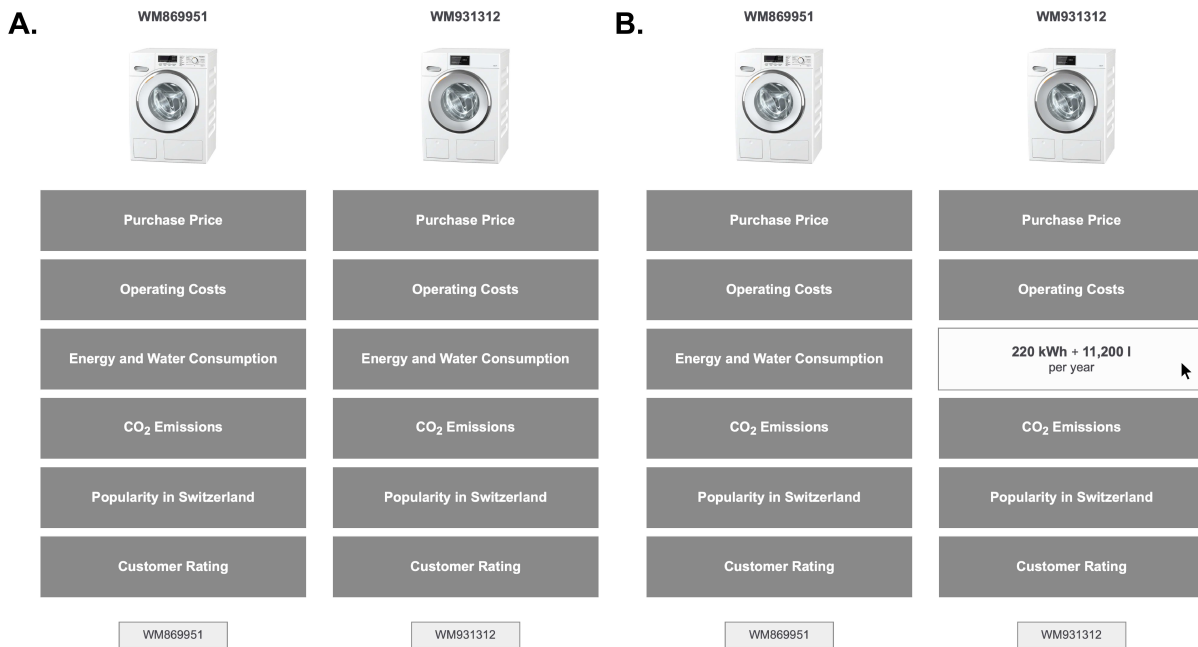
FIGURE 1: Example of a choice problem displayed with the process tracing tool MouselabWEB. Information about product attributes is concealed (see A) unless the cursor of the computer mouse is moved over the corresponding box (see B). The order of product options and attributes was counterbalanced.

selecting the comparatively more energy and water efficient product option in the absence and presence of attribute translations.[2]

The random effects structure of both multilevel models was selected based on the maximal complexity that was supported by our data (Barr, Levy, Scheepers & Tily, 2013).

The relation between attribute translations, attention allocation, and product choices was analyzed through a mediation analysis using the R package `mediation` (Tingley, Yamamoto, Hirose, Keele & Imai, 2013). This analysis was based on two multilevel regression models that estimated (1) the relation between attribute translations and subjects' allocation of attention across choice options, and (2) the relation between attribute translations and the selection of energy and water efficient product options when controlling for attention allocation. Due to the computational constraints of the R package, models were limited to two levels with random intercepts for subject only. The mediation was tested based on a quasi-Bayesian Monte Carlo method with 10,000 simulations.

2.2 Results

To control for the influence of spurious information acquisitions that may have occurred during the experiment, all

attribute acquisitions below 200 ms were removed from the dataset. In addition, cases with unusually low or high acquisition frequencies and decision durations were removed to exclude unengaged or distracted subjects. More specifically, observations with less than two attribute acquisitions per choice task were removed to ensure that choices were based on the comparison of at least two product attributes. Likewise, observations with an overall decision duration below 400 ms[3] or above a cut-off value of three median absolute deviations above the median were removed. Medians and absolute median deviations were computed separately for each condition to account for differences in the number of product attributes and their effects on overall decision duration. Based on these criteria, 7.43 percent of observations were removed from our analyses, a value common for process tracing studies (Willemsen & Johnson, 2019).

Since the attribute translations provided in this experiment were based on energy and water consumption, we exclusively focused on decisions that required a trade-off either in favor of or against energy efficiency. Choice problems in which the presented product options were identical in terms of consumption were therefore excluded from the analyses (see choice problems 5, 8, and 10 in Table B1), resulting in data for 3,958 choices.

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[2]`glmer(choice ~ (session | subject) + (1 | problem) + session, data = mydata, family = binomial(link = "logit"))`.

[3]Adjusting the minimum decision duration to higher and thus more restrictive values (800 ms, 1,200 ms, or 4,000 ms) resulted in similar findings and did not affect any of the conclusions reported in this paper. The results of our robustness checks are reported in Appendix D.
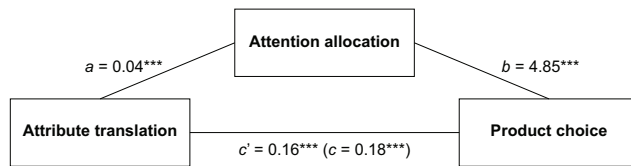
FIGURE 2: Allocation of attention across choice options mediates the relation between attribute translations and product choice.

Allocation of attention. On average, subjects inspected the presented product attributes 15.13 times ($SD = 7.40$, $Mdn = 14$) and for a total of 10.03 seconds ($SD = 5.28$, $Mdn = 8.95$) per choice problem. The mean duration of decisions was 12.64 seconds ($SD = 5.82$, $Mdn = 11.53$). Energy and water efficient product options generally received more attention compared to their alternatives, as indicated by the relative difference in overall acquisition duration in the absence of attribute translations (t_1), $\Delta M_{t_1} = 0.04$ ($SD = 0.23$), $t(16.54) = 2.79$, $p = .01$ (for details regarding the calculation of the relative difference scores, see Equation 1). Consistent with our prediction that the translation of energy and water consumption would bias the information acquisition process in favor of ecological choice options, we found the provision of attribute translations at t_2 to further increase the attentional prioritization of energy and water efficient product options, $\Delta M_{t_2} = 0.07$ ($SD = 0.23$), $b = 0.04$, 95% CI $[0.02, 0.05]$, $t(180.51) = 4.53$, $p < .001$. Note that the overall levels of attentional prioritization of choice options were only subtle, which is consistent with previous research on the role of visual attention in decision making (e.g., Kim, Seligman & Kable, 2012) and highlights the size of the effect of translations on pre-decisional information acquisition processes.

Product choice. In line with our hypothesis, the proportion of ecological product choices increased from 63.24 percent ($SD = 48.23$) in the absence of translations of energy and water consumption (t_1) to 81.47 percent ($SD = 38.86$) in the presence of translations (t_2). Multilevel logistic regression analysis confirmed that the provision of attribute translations significantly increased the probability of choosing the comparatively more energy and water efficient product option, $OR = 7.72$, 95% CI $[5.22, 11.86]$, $z = 9.85$, $p < .001$.

Link between attention allocation and choice. Consistent with previous research pointing to the causal link between attention and choice (Armel et al., 2008; Krajbich et al., 2010; Lim et al., 2011; Pachur et al., 2018; Pärnamets et al., 2015), individuals' allocation of attention across product options was found to significantly predict choice. Specifically, a stronger attentional prioritization of the energy and

water efficient product option was associated with a higher probability of ultimately choosing the efficient choice option, $OR = 188.89$, 95% CI $[101.48, 359.19]$, $z = 16.27$, $p < .001$.

To test whether the effects of attribute translations on subjects' product choices were linked to an increase in attentional prioritization of energy and water efficient choice options, we conducted a mediation analysis (see section *Data analysis* for details). This analysis showed that the relation between attribute translations and product choices was indeed partially mediated by the relative attention subjects directed towards choice options. As shown in Figure 2, the partial mediation was indicated by a significant indirect effect of attribute translations via attention allocation, $b = 0.02$, 95% CI $[0.01, 0.03]$, $p < .001$, proportion mediated = 0.13.

2.3 Discussion

The results of Study 1 support our proposition that the directional capacities of attribute translations are based on an attentional process that guides pre-decisional information acquisition and integration processes towards choice options that are most congruent with the concerns and objectives highlighted by translations. On a cognitive level, this was reflected in an increased attentional prioritization of ecological choice options in the presence of translations of energy and water consumption. On a behavioral level, the observed changes in attention allocation were associated with an increase in preference for energy and water efficient products and willingness to accept other less favorable product characteristics in return. Although the attentional prioritization of choice options only partially accounted for the observed variance in behavior and thus did not completely mediate the effects of attribute translations on product choices, these findings increase our understanding of the cognitive mechanisms that underlie the directional capacities of decision signposts.

Based on our experimental design, we cannot exclude the possibility that the observed changes in decision making were not caused by the presence of attribute translations but in fact by repetition and practice effects that may have resulted from the repeated measurement of choice problems at t_1 and t_2. To address this issue, Study 2 added an experimental control group that allowed us to investigate individuals' consistency in attention allocation and product choices in the absence of translations across time. Furthermore, it is not clear whether the cognitive and behavioral changes we observed in the presence of translations were driven by the content of attribute translations or a change in the decision environment: Whereas the balance between choice options in the number of favorable and unfavorable product attributes was even in the absence of attribute translation, this balance became skewed towards more energy and water efficient choice options in the presence of attribute translations.

Therefore, the results may have also been driven by a tallying heuristic (Gigerenzer & Gaissmaier, 2011; Gigerenzer & Goldstein, 1996), in which choice options are valued based on the mere number of comparatively favorable attributes. Indeed, a supplementary analysis of transition patterns between product attributes and choice alternatives showed a significant increase between t_1 and t_2 in comparative search patterns as measured by the *SM* index (Böckenholt & Hynan, 1994), $M_{t_1} = -0.98\,(SD = 0.41)$, $M_{t_2} = -1.22\,(SD = 0.38)$, $t(180.80) = -15.46$, $p < .001$. This increase in systematic information search is consistent with the use of a tallying heuristic. Previous research has provided first evidence that the effects of attribute translations may be based on both the information translations provide and the changes they cause in the decision environment (Ungemach et al., 2018). To further clarify this issue, Study 2 investigated the interplay of informational and contextual elements of attribute translations in guiding decision making.

3   Study 2

The aim of the second study was to clarify the choice architectural determinants of attribute translations and to investigate the interplay of informational elements, in this case, the content of translations, and contextual elements, in this case, the number of favorable product attributes, on the cognitive and behavioral effects found in Study 1. As in Study 1, we examined individuals' allocation of attention during the acquisition of product information as well as their subsequent product choices in the absence and presence of translations of energy and water consumption. In contrast to Study 1, translations were varied across experimental conditions to assess the impact of information on decision making. Concretely, we manipulated the focus of translations to be on either economic or environmental concerns and to be presented in either numeric or evaluative format. Based on *General Evaluability Theory* (Hsee & Zhang, 2010), we hypothesized significant differences between translations in their effectiveness to direct allocation of attention and choices. Specifically, we predicted that translations conveying evaluative information would have a larger impact on the attentional prioritization and ultimate selection of choice options than would translations conveying numeric information.

To assess the extent to which contextual changes in the decision environment moderate the directional effects of attribute translations on decision making, we further manipulated the number of favorable product attributes that was presented per choice option. In line with previous research (Alba & Marmorstein, 1987; Russo & Dosher, 1983; Ungemach et al., 2018; Zhang et al., 2006), we predicted that a numerical advantage in product attributes favoring the energy and water efficient choice option would amplify the cognitive and behavioral effects of translations.

3.1   Method

Design. To investigate the interplay of informational and contextual elements of attribute translations on decision making, we employed a 2 (attribute translations: absent [t_1] vs. present [t_2]; within subjects) × 4 (translation of energy and water consumption: operating costs vs. carbon emissions vs. rating of environmental friendliness vs. no translation; between subjects) × 2 (translation of purchase price: absent vs. present; between subjects) mixed factorial design (see Figure C1 of Appendix C). The control condition in which no translation of energy and water consumption was present at t_2 was introduced to examine the consistency in decision making across experimental sessions. As in Study 1, the dependent variables were acquisition of product information as well as subsequent product choices.

Subjects. To account for the complexity of our research design and to validate the findings of Study 1 within the general population, a substantially larger and more heterogeneous sample of 792 individuals (52.53% female, mean age = 53.44 years, $SD = 13.78$) was recruited for this experiment through a professional panel provider in Germany. Sample size was based on an *a priori* target of 100 subjects per condition, which due to the addition of process measures was slightly higher than the sample sizes of previous studies on attribute translations (e.g., Camilleri, Larrick, Hossain & Patino-Echeverri, 2019; Ungemach et al., 2018). Subjects were paid a flat fee for their participation. Ninety-one subjects completed only the first part of the study and were therefore excluded from the analyses, leading to a final sample of 701 individuals.

Materials and procedure. The study was conducted in two online experimental sessions following a survey that assessed general sociodemographic information, such as subjects' gender and age. Both sessions started with an exercise to familiarize subjects with MouselabWEB and to check their understanding of the choice environment. Following this exercise, the sessions continued with the choice task, which was based on a set of choice problems similar to that used in Study 1. While the underlying trade-off structure of choice problems remained the same, purchase prices and operating costs of product options were adjusted to account for differences between the German and Swiss market (see Table B1 of Appendix B).

Similar to Study 1, the first experimental session only provided information about the price, energy and water consumption, and popularity of appliances to establish a baseline measurement of subjects' product preferences. In the second session 13–24 days ($M = 17.12$, $SD = 1.79$) later, these descriptions were complemented by one of three translations of energy and water consumption, namely the estimated operating costs of the appliance, the incurred carbon emissions,

or a customer rating of environmental friendliness which was expressed using a five-step grading system that ranged from "insufficient" to "excellent". Ratings of environmental friendliness were changed from the visually salient leaf scale used in Study 1 to a written grading scale to increase the comparability of attributes and reduce the possibly confounding effects of visual salience on decision making.

To investigate consistency in decision making and thus address possible repetition and practice effects in our experimental design, an additional control condition was included in which no translation of energy and water consumption was presented. Half of the subjects were further provided with the monthly installment fees of appliances that were directly derived from the purchase price, with higher prices resulting in higher installment fees. The addition of this price translation balanced out the number of favorable attributes per choice option and thus allowed us to test for the effects of contextual elements of attribute translations on decision making.

Data analysis. To analyze the effects of informational and contextual elements of attribute translations on decision making, we extended our multilevel regression models used in Study 1 to include fixed effects for the type of translation of energy and water consumption, the presence of a price translation, and the corresponding interaction terms.[4]

Across analyses, Bonferroni corrections were applied in cases of multiple *post hoc* comparisons between factor levels. The reported p-values are adjusted for any corrections applied.

3.2   Results

Applying the same criteria on the quality of information acquisition data as in Study 1, 9.75 percent of observations were excluded from the analyses[5]. Moreover, only choice problems in which the presented product options differed with respect to their energy and water consumption were considered, resulting in a final sample of 15,089 observations.

Allocation of attention. On average, product attributes were inspected 10.77 times ($SD = 5.25$, $Mdn = 10$) and for a total of 9.45 seconds ($SD = 5.60$, $Mdn = 8.13$) per choice problem. The mean duration of decisions was

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[4]lmer(attention ~ (session | subject) + (1 | problem) + session * consumption_translation * price_translation, data = mydata);
glmer(choice ~ (session | subject) + (1 | problem) + session * consumption_translation * price_translation, data = mydata, family = binomial(link = "logit")).

[5]Similar to Study 1, adjusting the minimum decision duration to higher and thus more restrictive values (800 ms, 1,200 ms, or 4,000 ms) resulted in similar findings and did not affect any of the conclusions reported in this paper. The results of our robustness checks are reported in Appendix D.

13.83 seconds ($SD = 7.17$, $Mdn = 12.15$). Analyses of attention allocation in the control condition suggested that subjects' attention towards choice options was generally consistent across experimental sessions, $b = -0.003$, 95% CI $[-0.021, 0.0162]$, $t(700.58) = -0.28$, $p = .78$. In the presence of attribute translations, however, the allocation of attention across product options changed significantly, $F(6, 686.31) = 2.59$, $p = .02$ (see Table 1), confirming our proposition that attribute translations affect the information acquisition and integration process through visual attention.

Multilevel linear regression analyses showed that the allocation of attention was significantly affected by the type of translation of energy and water consumption, as indicated by an interaction of presence (t_1 vs. t_2) and type of translation on the relative difference in acquisition duration between choice options, $F(3, 685.22) = 5.46$, $p < .01$. *Post hoc* comparisons between the varying translations of energy and water consumption showed that this effect was driven by observations in conditions that presented ratings of environmental friendliness, as the presence of these ratings resulted in a substantial increase in attention towards energy and water efficient product options compared to the baseline (t_1), $b = 0.044$, 95% CI $[0.025, 0.064]$, $t(663.03) = 4.38$, $p < .001$). The presence of carbon emissions ($b = 0.013$, 95% CI $[-0.008, 0.033]$, $t(684.75) = 1.18$, $p = .71$) and operation costs ($b = .006$, 95% CI $[-0.015, 0.028]$, $t(698.05) = 0.56$, $p > .99$) did not affect subjects' allocation of attention across choice options.

Contrary to our predictions, the presence of a price translation did not moderate the effects of translations of energy and water consumption on the allocation of attention across product options, as indicated by the nonsignificant three-way interaction of presence of translations (t_1 vs. t_2), type of translation of energy and water consumption, and presence of a price translation, $F(3, 685.24) = 1.31$, $p = .27$. All in all, the results thus support an informational rather than contextual account of attribute translations, highlighting the importance of information over the structure of the decision environment to explain the directional effects of attribute translations on decision making.

Product choice. In line with our previous findings, the proportion of ecological product choices increased from 52.86 percent ($SD = 49.92$) to an average of 63.17 percent ($SD = 48.24$) in the presence of translations of energy and water consumption. An analysis of product choices in the control condition found subjects' product selections to be generally consistent across t_1 and t_2 ($OR = 0.86$, 95% CI $[0.55, 1.34]$, $z = -0.68$, $p = 0.50$), indicating that the increase in ecological product choices was indeed caused by the presence of attribute translations rather than the repeated presentation of choice problems.

Multilevel logistic regression analysis tested the extent to which the observed increase in ecological product choices

TABLE 1: Average relative difference in acquisition duration ($\Delta t_{options}$) between ecological and non-ecological product options in absence (t_1) and presence (t_2) of attribute translations. Standard deviations are provided in parentheses. Model estimates indicate difference in attention allocation between t_1 and t_2.

Consumption translation	n	Price translation	Attribute translations		
			Absent (t_1)	Present (t_2)	B (SE)
Control	104	Absent	0.003	0.002	−0.003
			(0.230)	(0.247)	(0.010)
	79	Present	−0.001	−0.018	−0.016
			(0.213)	(0.236)	(0.011)
Operating costs	79	Absent	−0.005	0.003	0.006
			(0.240)	(0.240)	(0.011)
	85	Present	0.011	0.032	0.020
			(0.203)	(0.243)	(0.011)
Carbon emissions	84	Absent	0.005	0.018	0.013
			(0.244)	(0.239)	(0.011)
	92	Present	0.004	0.003	−0.002
			(0.234)	(0.231)	(0.010)
Environmental friendliness rating	89	Absent	0.009	0.054	0.044***
			(0.235)	(0.231)	(0.010)
	89	Present	0.006	0.025	0.018†
			(0.217)	(0.237)	(0.010)

Note. †$p < .10$; ***$p < .001$.

was driven by the information translations provided and the contextual changes they caused in the decision environment. Consistent with our hypothesis, this analysis found product choices to be significantly affected by information, as indicated by an interaction effect of presence and type of translation of energy and water consumption, $\chi^2(3) = 131.12$, $p < .001$ (Figure 3). Follow-up comparisons between the varying consumption translations showed that this effect was driven by conditions in which ratings of environmental friendliness were presented, as the presence of these ratings caused a substantial increase in ecological product choices compared to the baseline (t_1), $OR = 17.29$, 95% CI [11.01, 28.46], $z = 11.35$, $p < .001$. Neither the provision of carbon emissions ($OR = 1.73$, 95% CI [1.04, 2.88], $z = 2.11$, $p = .11$) nor operating costs ($OR = 1.61$, 95% CI [0.96, 2.69], $z = 1.82$, $p = .21$) had a significant impact on product choices. This difference between varying types of translations supports the notion that the extent to which attribute translations affect preferences largely depends on the way in which the translated information is presented. Specifically, it confirms our hypothesis that translations conveying evaluative information are more effective in guiding decisions than translations conveying numeric information.

In contrast, the presence of a price translation did not moderate the effects of translations of energy and water consumption on product choice as we originally predicted, $\chi^2(3) = 4.80$, $p = .19$. The number of favorable attributes per choice option thus did not have an impact on the effectiveness of attribute translations. Based on these results, we conclude that the behavioral effects we observed in the presence of varying consumption translations were primarily driven by information rather than contextual components of the decision environment.

Link between attention allocation and choice. In line with our previous findings, individuals' allocation of attention was found to predict choice, with stronger attentional prioritization of the energy and water efficient product option being associated with a higher probability of choosing this option, $OR = 113.59$, 95% CI [78.78, 164.84], $z = 25.16$, $p < .001$.

3.3   Discussion

The results of Study 2 provide further support for our proposition that attribute translations direct decision making through the attentional prioritization of choice options that are most congruent with the concerns and objectives activated through the translation. On a cognitive level, this was reflected in an increase of relative attention towards
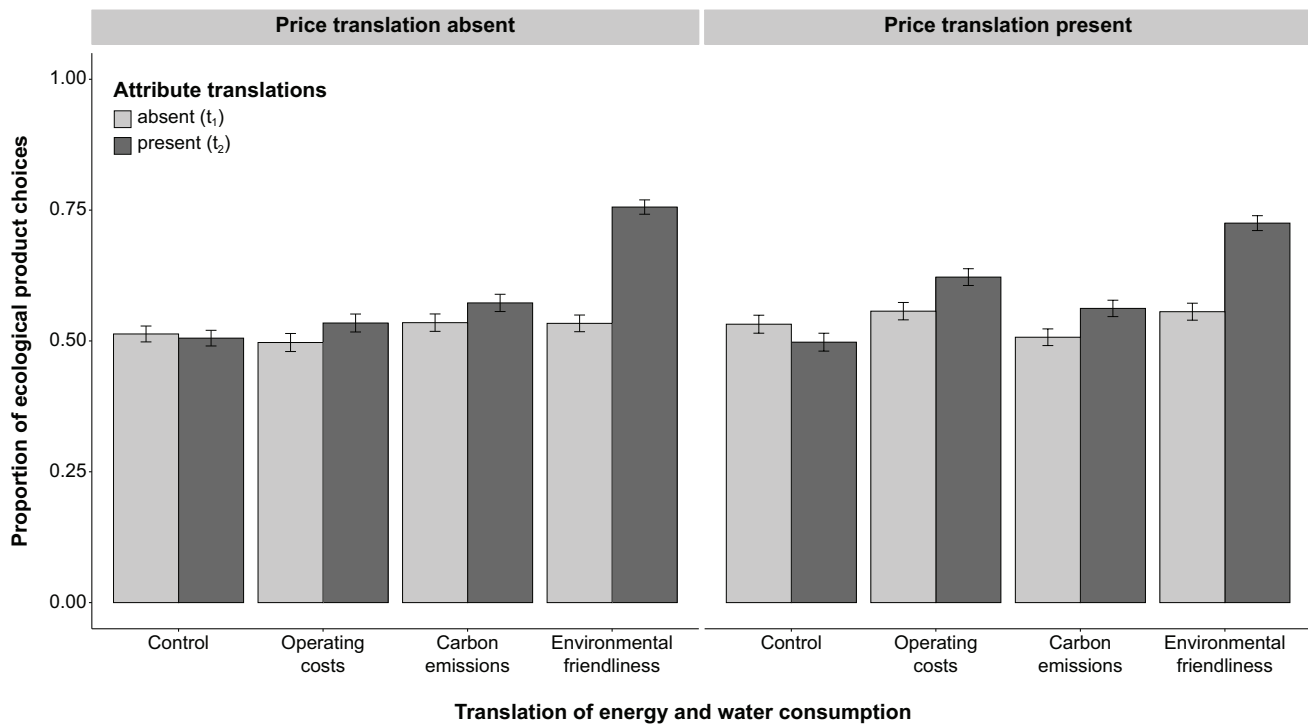
FIGURE 3: Proportion of ecological product choices in the absence and presence of translations of energy and water consumption and price. Error bars represent the standard error of the mean.

ecological choice options in the presence of translations of energy and water consumption. On a behavioral level, the observed changes in attention allocation were associated with an increase in individuals' preference for energy and water efficient product options.

It is important to note that the effectiveness of translations was moderated by elements of the decision environment. Indeed, the aim of Study 2 was not only to provide additional evidence for our proposition of the cognitive mechanisms underlying the signpost effect of attribute translations but also to clarify the impact of informational and contextual aspects of translations on their effectiveness to guide decision making. In line with *General Evaluability Theory* (Hsee & Zhang, 2010) and research demonstrating that individuals experience difficulties in processing and considering numeric information in their decisions (Peters et al., 2009, 2006), we found the directional effects of attribute translations to only occur in the presence of evaluative information (i.e., a rating of environmental friendliness) but not in the presence of numeric information (i.e., the expected costs and amount of carbon emissions associated with operating an appliance). Contrary to previous research (Ungemach et al., 2018), the number of favorable product attributes did not influence the effectiveness of attribute translations, suggesting that the directional effects of translations were primarily elicited by informational rather than contextual aspects of the decision environment.

4   General Discussion

In this paper, we investigated the cognitive and behavioral effects of attribute translations on decision making in the energy domain. Across two studies, we have shown that the translation of abstract product attributes into more accessible information can provide valuable guidance for individuals and facilitate both personally and socially desirable purchase decisions. In particular, we found that the expression of commonly used consumption metrics in terms of highly correlated aspects, such as environmental friendliness, increased the selection of energy efficient products. This result is in line with previous research that has pointed to the positive effects of attribute translations on decision making (Camilleri, Cam & Hoffmann, 2019; Camilleri, Larrick, et al., 2019; Ungemach et al., 2018).

In addition to the effects of attribute translations on product choices, we have also provided first empirical evidence for the cognitive mechanisms that underlie and drive these effects. Specifically, we demonstrated that the directional capacities of translations are based on an attentional prioritization process that directs pre-decisional information acquisition and integration processes towards choice options that are most congruent with the concerns and objectives highlighted by translations. This finding contributes to our understanding of attribute translations as it complements previous research, which focused primarily on the behav-

ioral effects of translations on decision making (Camilleri, Cam, et al., 2019; Ungemach et al., 2018). The current study is among the first to investigate the cognitive correlates of a choice architectural intervention. As such, it not only provides insights into the mechanisms underlying attribute translations but also has implications for the study of choice architecture overall. As of this point, decision processes have mainly been treated as a black box in the field of choice architecture. Our findings, however, illustrate that the study of cognitive processes allows the field to adequately develop and evaluate theoretical frameworks that explain the behavioral phenomena we observe in choice architecture.

Besides the psychological mechanisms underlying attribute translations, we show that there is a direct link between the effectiveness of translations and choice architectural principles of information presentation. First of all, our findings suggest that the translation of attributes affects decision making through the provision of supplementary information rather than contextual changes in the decision environment. As opposed to nudges, which are frequently criticized for capitalizing too powerfully on the shortcomings of human decision making, thereby restricting individuals in their actual autonomy to act upon their preferences (Hausman & Welch, 2010), attribute translations can thus be best understood as targeted, information-based decisions aids that aim to enhance individuals' decision making competencies (Camilleri, Cam, et al., 2019; Hertwig & Grüne-Yanoff, 2017). Second, our results highlight how seemingly similar translations can have different effects on the decision process as a function of their format. Specifically, we found that evaluative information had a particularly large impact on the decision making process, which is in line with previous research showing that individuals often bias their decision making towards highly evaluable information (Hsee, 1996; Hsee & Zhang, 2010). This bias may be explained in terms of the so-called processing fluency hypothesis, which states that individuals interpret the ease of information processing as a signal of the importance or quality of an attribute (Shah & Oppenheimer, 2007). Indeed, converging empirical evidence indicates that the ease of information processing increases significantly as a function of evaluability or the degree to which information can be mapped on to an evaluative scale (Peters et al., 2009).

The variance in effectiveness across translations poses the question to what extent subjects understood the high correlation between energy and water consumption and its translations. According to the signpost effect, attribute translations affect decision making through the activation of relevant but latent concerns and the provision of direction. Alternatively, it could be argued that the effects of translations are driven by changes in individuals' knowledge about attributes. In this view, translations affect decision making by increasing individuals' understanding of the relation between attributes, demonstrating, for example, the environmental relevance of

energy and water consumption. In their paper on the signpost effect of attribute translations, Ungemach et al. (2018) tested this knowledge-based account and investigated whether the provision of a greenhouse gas rating, as compared to a fuel efficiency measure of gallons per 100 miles, would increase individuals' knowledge about the relation between the annual fuel costs of a vehicle and its greenhouse gas emissions. No evidence for such an increase in knowledge was found, supporting the notion that attribute translations act as decision signposts which activate concerns and provide direction to the decision process rather than learning aids that facilitate individuals' understanding of the relation between attributes. Though our experimental design differed in some respect from the study by Ungemach and colleagues, we take their findings as an indication that the effects of attribute translations we observed in our experiments were driven by the activation and direction mechanisms of the signpost effect and not by differences in knowledge.

Another important question that arises from the present set of studies is to what extent demand effects may explain the observed impact of attribute translations on decision making. Based on previous research (e.g., Brown & Krishna, 2004; Leong, McKenzie, Sher & Müller-Trede, 2017; McKenzie & Nelson, 2003; Sher & McKenzie, 2006), it could be argued that the presentation of translations implicitly conveys information about the personal preferences of the choice architect, which may consequently lead individuals to act in accordance with these preferences. In their research on information leakage in policy making, McKenzie, Liersch & Finkelstein (2006), for example, found that individuals who followed a given choice default attributed their decision to inferences they had made about the personal preferences of the policy maker. Similarly, the provision of carbon emissions or environmental friendliness ratings in our experiments may have been interpreted as a prompt or recommendation to choose more environmentally responsible options. Due to the hypothetical nature of our experiments and the lack of financial incentives, we cannot entirely rule out the presence of such demand effects. The varying effectiveness of attribute translations in guiding decision making in Study 2, however, suggests that the effects of translations cannot be driven by demand effects alone, as translations should have conveyed similar preferences across conditions. This conclusion is supported by a recent line of research which has found demand effects to have only a small to modest influence on the treatment effects of experimental research (de Quidt, Haushofer & Roth, 2018; Mummolo & Peterson, 2019).

In addition to the theoretical implications, our results are also of practical relevance. Specifically, they demonstrate that attribute translations are an effective tool to guide consumers towards decisions that are beneficial for both the decision maker and society. The large effect sizes of the behavior change we observed in the presence of attribute

translations indicate that this choice architectural technique is indeed a very promising tool that should receive more attention in policy making. Attribute translations lend themselves particularly well to the integration in energy labels, as illustrated by the current fuel economy and environment label of the U.S. Environmental Protection Agency. Other labels that include translations, such as the EnergyGuide label, presently focus on economic incentives of energy consumption alone, which neglects the increasingly prevalent environmental concerns of consumers. Our findings highlight the importance and potential of addressing these concerns and provide clear guidelines for the development of effective translations that may be integrated into current labeling schemes.

While the present set of studies has provided insights from both theoretical and practical perspectives, it does come with limitations. First, our experimental paradigm does not allow for causal inferences regarding the relation between the cognitive and behavioral effects of attribute translations on decision making. Since we did not manipulate individuals' allocation of attention during information acquisition, we cannot exclude the possibility that processes other than the ones described here caused the observed changes in cognition and behavior. Future research may want to clarify the causal chain between pre-decisional processes and choices to confirm the psychological mechanisms underlying decisions signposts that we propose in this paper. Specifically, this research may investigate whether the effects of attribute translations on choices are affected by experimentally manipulated changes in the allocation of attention. For example, we would expect to see a significant decrease in the effectiveness of translations when attention across choice options is manipulated to prioritize concern-incongruent rather than congruent options. In their study on the role of attention in prospect theory, Pachur et al. (2018) manipulated attention through varying the presentation time of information within the MouselabWEB environment. A similar approach may be used to test the causal link between attention and choice in the context of attribute translations by manipulating the relative opening times of choice options that are congruent with the concerns activated by translations vs. options that are incongruent with these concerns.

Second, we did not consider individual differences that may affect the effectiveness of translations. Based on previous research (van der Laan et al., 2017; Verplanken & Holland, 2002), the general directional mechanisms of attribute translations described in this paper are likely to be moderated by personality characteristics, such as values and beliefs. Indeed, Ungemach et al. (2018) found that the translation of fuel economy into a greenhouse gas rating was particularly effective for individuals who endorsed pro-environmental beliefs. Future research may build on this finding and investigate the influence of personality characteristics on both cognitive and behavioral effects of translations. Along the same

lines, research has shown that psychological factors such as numeracy and expertise can affect individuals' comprehension and use of information (Peters et al., 2006). Future research should examine how these factors affect responses to varying attribute translations to identify presentation formats that maximize the signpost potential of translations. Another interesting and important avenue for future research would be to investigate the concept of attribute translations in other behavioral domains, such as health and finances, which would validate the generalizability of the signpost effect and its usefulness beyond the environmental domain.

In conclusion, the current study has demonstrated that the translation of product attributes can help individuals navigate complex decision environments and support personally and socially desirable choices. Using discrete choice paradigms and process tracing techniques, we provide empirical evidence for the psychological and choice architectural mechanisms underlying this effect and discuss concrete recommendations for the development and implementation of behavioral interventions and policies.

5　Context of Research

The present set of experiments is part of a broader research program that aims to identify explicit and implicit determinants of decision making. This research is largely inspired by the common observation that consumers do not seem to follow the principles of rationality that are central to normative models of decision making. As we describe before, this deviation from rationality is particularly prevalent in the environmental domain, where investment decisions are only made infrequently and are impaired by hyperbolic discounting of future benefits (Weber, 2017). Placed at the interface of science, practice, and policy, our work investigates the psychological mechanisms underlying environmentally relevant decisions to contribute to our understanding of human decision making and inform the development of interventions that may help individuals to make better decisions for themselves and society. Future research will aim to expand the current line of research on attribute translations and examine individual differences in response to attribute translations as a function of sociodemographic and personality characteristics.

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Appendix A: Experimental Design of Study 1

t_1	t_2	
Price	**Price**	**Operating costs**
Energy and water consumption	**Energy and water consumption** +	**Carbon emissions**
Popularity	**Popularity**	**Environmental friendliness**

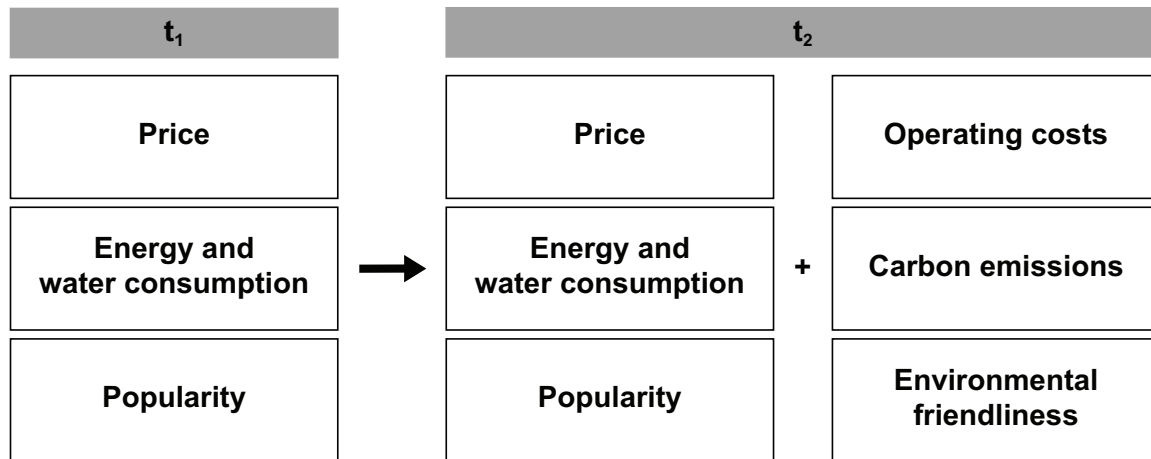FIGURE A1: Graphical representation of experimental design used in Study 1. At baseline (t_1), choice options were described in terms of their price, energy and water consumption, and popularity. At t_2, the same product information was complemented by three translations of energy and water consumption.

Appendix B: Set of Choice Problems

TABLE B1: Representation of set of choice problems presented in Study 1 and 2.

Choice problem	Option A			Option B		
	Price	Consumption	Popularity	Price	Consumption	Popularity
1	CHF 669	190 kWh, 10,300 l	Top 100	CHF 669	220 kWh, 11,200 l	Top 50
2	CHF 669	190 kWh, 10,300 l	Top 100	CHF 1,059	160 kWh, 9,400 l	Top 100
3	CHF 669	190 kWh, 10,300 l	Top 100	CHF 1,059	220 kWh, 11,200 l	Top 10
4	CHF 669	190 kWh, 10,300 l	Top 100	CHF 1,449	160 kWh, 9,400 l	Top 50
5	CHF 669	190 kWh, 10,300 l	Top 100	CHF 1,449	190 kWh, 10,300 l	Top 10
6	CHF 669	220 kWh, 11,200 l	Top 50	CHF 1,059	160 kWh, 9,400 l	Top 100
7	CHF 669	220 kWh, 11,200 l	Top 50	CHF 1,449	160 kWh, 9,400 l	Top 50
8	CHF 669	220 kWh, 11,200 l	Top 50	CHF 1,059	220 kWh, 11,200 l	Top 10
9	CHF 669	220 kWh, 11,200 l	Top 50	CHF 1,449	190 kWh, 10,300 l	Top 10
10	CHF 1,059	160 kWh, 9,400 l	Top 100	CHF 1,449	160 kWh, 9,400 l	Top 50
11	CHF 1,059	160 kWh, 9,400 l	Top 100	CHF 1,059	220 kWh, 11,200 l	Top 10
12	CHF 1,059	160 kWh, 9,400 l	Top 100	CHF 1,449	190 kWh, 10,300 l	Top 10
13	CHF 1,059	220 kWh, 11,200 l	Top 10	CHF 1,449	160 kWh, 9,400 l	Top 50
14	CHF 1,059	220 kWh, 11,200 l	Top 10	CHF 1,449	190 kWh, 10,300 l	Top 10
15	CHF 1,449	160 kWh, 9,400 l	Top 50	CHF 1,449	190 kWh, 10,300 l	Top 10

Notes. The order of product options and product attributes within each choice problem was randomized. In Study 2, prices were adjusted to the following values to account for differences between the German and Swiss market: EUR 529 [CHF 669]; EUR 939 [CHF 1,059]; EUR 1,349 [CHF 1,449].

TABLE B2: Representation of translations of energy and water consumption presented in Study 1 and 2.

Energy and water consumption	Translation		
	Operating costs	Carbon emissions	Environmental friendliness rating
160 kWh, 9,400 l	CHF 1,199.25	112 kg	*****
190 kWh, 10,300 l	CHF 1,369.13	134 kg	***
220 kWh, 11,200 l	CHF 1,539.00	155 kg	*

Notes. In Study 2, operating costs were adjusted to the following values to account for differences between the German and Swiss market: EUR 1,078.26 [CHF 1,199.25], EUR 1,255.34 [CHF 1,369.13], EUR 1,432.41 [CHF 1,539.00]. Samples of the MouselabWEB scripts used in Study 1 and 2 can be found on the OSF (https://osf.io/fqdra/).
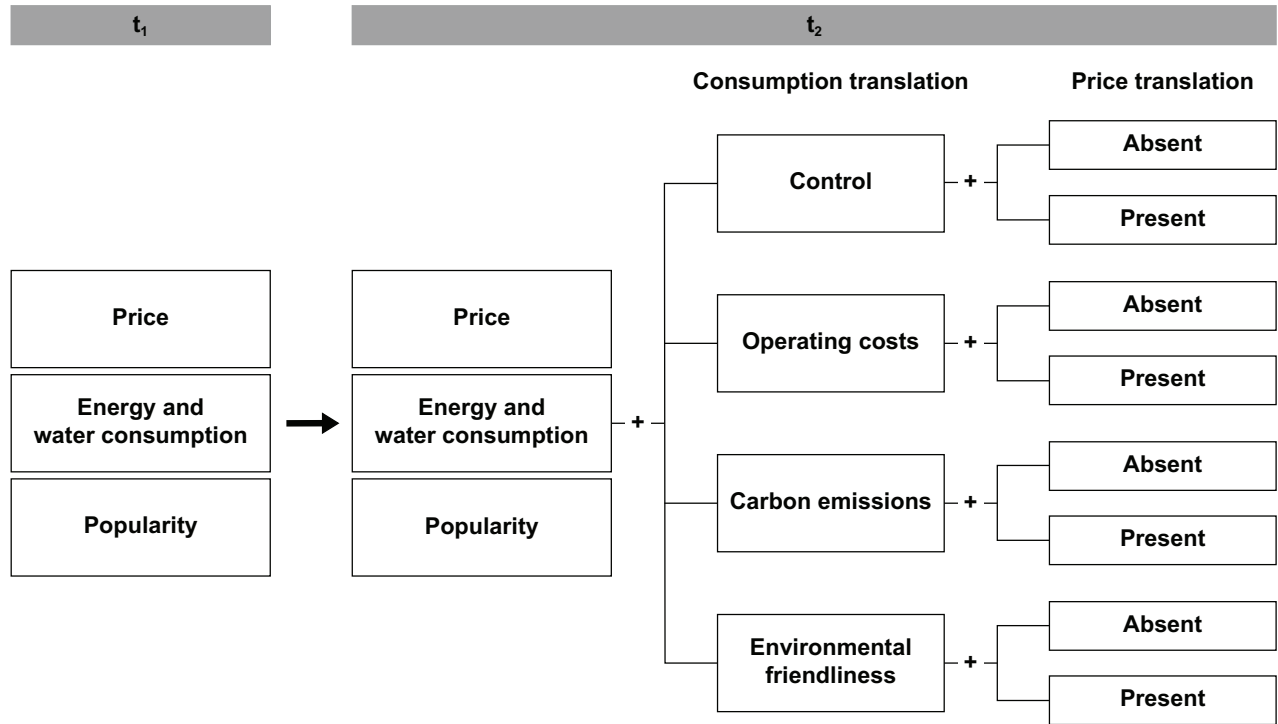
Appendix C: Experimental Design of Study 2

FIGURE C1: Graphical representation of experimental design used in Study 2. At baseline (t_1), choice options were described in terms of their price, energy and water consumption, and popularity. At t_2, the same product information was complemented by none (control) or one of three translations of energy and water consumption. Depending on the experimental condition, the number of comparatively favorable product attributes per choice option was balanced through the addition of a translation of price.

Appendix D: Statistical Robustness Checks

TABLE D1: Results of statistical robustness checks for Study 1. Table presents the main results under adjusted lower cut-off values for overall decision duration.

Test	Lower cut-off value			
	400 ms	800 ms	1,200 ms	4,000 ms
% data exclusion	7.43	7.43	7.43	9.24
Attention allocation	$b = 0.04$***	$b = 0.04$***	$b = 0.04$***	$b = 0.04$***
Product choice	$OR = 7.72$***	$OR = 7.72$***	$OR = 7.72$***	$OR = 7.79$***
Link between attention allocation and choice	$OR = 188.89$***	$OR = 188.89$***	$OR = 188.89$***	$OR = 191.58$***

Notes. ***$p < .001$.

TABLE D2: Results of statistical robustness checks for Study 2. Table presents the main results under adjusted lower cut-off values for overall decision duration.

Test	Lower cut-off value			
	400 ms	800 ms	1,200 ms	4,000 ms
% data exclusion	9.75	9.76	9.77	11.98
Consistency in attention allocation	$b = -0.003$	$b = -0.003$	$b = -0.003$	$b = -0.001$
Effect of consumption translation on attention allocation	$F(3, 685.22) = 5.46$**	$F(3, 685.23) = 5.46$**	$F(3, 685.23) = 5.46$**	$F(3, 669.18) = 5.64$***
Operating costs	$b = 0.006$	$b = 0.006$	$b = 0.006$	$b = 0.007$
Carbon emissions	$b = 0.013$	$b = 0.013$	$b = 0.013$	$b = 0.015$
Environmental friendliness rating	$b = 0.044$***	$b = 0.044$***	$b = 0.044$***	$b = 0.042$***
Effect of consumption translation × price translation on attention	$F(3, 685.24) = 1.31$	$F(3, 685.24) = 1.30$	$F(3, 685.24) = 1.30$	$F(3, 669.20) = 1.60$
Consistency in product choice	$OR = 0.86$	$OR = 0.85$	$OR = 0.87$	$OR = 0.84$
Effect of consumption translation on product choice	$\chi^2(3) = 131.12$***	$\chi^2(3) = 131.39$***	$\chi^2(3) = 130.70$***	$\chi^2(3) = 131.90$***
Operating costs	$OR = 1.61$	$OR = 1.61$	$OR = 1.61$	$OR = 1.56$
Carbon emissions	$OR = 1.73$	$OR = 1.73$	$OR = 1.73$	$OR = 1.77^\dagger$
Environmental friendliness rating	$OR = 17.29$***	$OR = 17.27$***	$OR = 17.30$***	$OR = 17.69$***
Effect of consumption translation × price translation on product choice	$\chi^2(3) = 4.80$	$\chi^2(3) = 4.80$	$\chi^2(3) = 4.76$	$\chi^2(3) = 5.14$
Link between attention allocation and choice	$OR = 113.59$***	$OR = 113.54$***	$OR = 113.54$***	$OR = 128.00$***

Notes. $^\dagger p < .10$; **$p < .01$; ***$p < .001$.

Appendix E: Analysis of Stimuli Characteristics

To exclude exogenous variance in product information (e.g., the amount of information presented for each attribute) as a driving mechanism of the effects reported in this paper, we conducted an analysis of the average digit length of attributes presented in the absence (t_1) and presence (t_2) of attribute translations. Based on previous research (e.g., Schulte-Mecklenbeck, Kühberger, Gagl, & Hutzler, 2017), we would expect to see a negative relation between the average digit length of attributes and the effects of attribute translations on the attentional prioritization of choice options, in that longer and thus potentially more complicated information has less influence on the identification of an initial leader and the resulting allocation of attention across options. This prediction was not confirmed by our analyses: In Study 1, no difference was found in the average digit length of attributes presented at t_1 and t_2, $M_{t_1} = 30.56$ ($SD = 13.52$), $M_{t_2} = 30.11$ ($SD = 11.75$), $t(157.77) = 0.27$, $p = 0.79$. In Study 2, changes in the average digit length of attributes were more pronounced compared to Study 1 (see Table E1 for details). In contrast to the predictions of previous research though, the largest effects of attribute translations on the allocation of attention were found in conditions with the longest digit lengths of attributes. We take these findings as an indication that the effects of attribute translations on decision making were not primarily driven by variance in the amount of information presented.

TABLE E1: Average digit length of product attributes across experimental conditions in Study 2. Standard deviations are provided in parentheses. T-values refer to the difference in average digit length between t_1 and t_2.

Consumption translation	Price translation	Attribute translations		
		Absent (t_1)	Present (t_2)	t-value
Control	Absent	32.78 (7.34)	32.78 (7.34)	
	Present	32.78 (7.34)	33.92 (6.65)	1.16
Operating costs	Absent	32.78 (7.34)	34.08 (6.74)	1.32
	Present	32.78 (7.34)	34.73 (6.17)	2.12*
Carbon emissions	Absent	32.78 (7.34)	34.83 (7.29)	2.01
	Present	32.78 (7.34)	35.33 (6.59)	2.71*
Environmental friendliness rating	Absent	32.78 (7.34)	36.33 (8.89)	3.17**
	Present	32.78 (7.34)	36.53 (7.96)	3.72***

Note. *$p < .05$; **$p < .01$; ***$p < .001$.