

**The Influence of Goal Frames and Value Orientations on the Motivation to Engage in
Pro-Environmental Behaviour**

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Abstract

One possibility to reduce greenhouse gas emissions is through digital feedback for energy consumption (e.g., graphical representations) in the residential sector. To maximise the motivation to engage in pro-environmental behaviour (PEB), goal framing theory has been commonly used in this context, being concerned with the framing of information and the salience of goals. Possibly moderating the relationship between goal frames and PEB are individual value orientations and the willingness to give up comfort. This explanatory research attempted to investigate this relationship by using an experimental design of 3 (Visualisation: control versus energy versus money) x 2 (Motivation to Engage in PEB: pre versus post measurement). The visualisations were designed to depict the hedonic (energy) and gain (money) goal frame. The results did not yield any significant effects, except for a marginally significant interaction effect of the gain goal frame and biospheric value orientation. Future research should attempt to understand the joint effect of gain goal frame and biospheric value orientation on PEB better and to investigate possible third variables influencing the relationship between goal frames and PEB. Advancing the understanding in this context might contribute to make visual feedback about energy consumption more effective and lead to more energy-conscious behaviour.

Keywords: goal framing theory, value orientation, pro-environmental behaviour, visual feedback, smart meter.

The Influence of Goal Frames and Value Orientations on the Motivation to Engage in Pro-Environmental Behaviours

Recently, the Intergovernmental Panel on Climate Change (IPCC) published the Synthesis Report of the Sixth Assessment Report (AR6) (IPCC, 2023), communicating a further augmentation of greenhouse gas (GHG) emissions, consequently affecting nature and humans (IPCC, 2023). To combat this augmentation, the associated climate change and its tremendous consequences, laws and treaties have been introduced to reduce CO₂ emissions, like the Paris agreement in 2015 (United Nations: Climate Change, n.d.) and the EU's proposed 2030 climate and energy framework (European Commission, n.d.).

One pivotal factor influencing human made GHG emissions is energy consumption (European Environment Agency [EEA], 2023). In 2020, the EU's final energy consumption (i.e., the overall energy consumption of end users) was mainly impacted by three sectors, namely transport, households, and industry with an energy consumption of 28.4%, 28% and 26.1%, respectively (Eurostat, 2022). Tackling energy reduction in the residential sector, which represents the second largest polluter, and thus fighting anthropogenic climate change is one of the fastest and most cost-effective options in this matter (International Energy Agency [IEA], 2022). This does not only bear relevance on an environmental, global level but also on an individual, monetary level since energy reduction is associated with financial benefits (IEA, 2022). Underpinning the latter aspect is the energy price rise in 2022 due to the Russian attack on Ukraine and EU's dependence on Russian supplies (Adolfson et al., 2022).

To address residential energy consumption and promote so-called pro-environmental behaviour (PEB), one might consider using different approaches (Steg & Vlek, 2009). For instance, the teaching role of feedback offers a valuable option for enhancing consciousness about energy consumption among individuals (IEA, 2022), which has also been appreciated by Piaget (1964). According to his theory, individuals learn most effectively when experiencing an active assimilation, that is the integration of new information into already existing knowledge structures. Applying this to the environmental context signifies that individuals might learn best to engage in PEB when being provided with feedback about their energy consumption behaviours, which has been supported by several studies, indicating promising effects of feedback on energy reduction by, on average, 4-12% (Nachreiner et al., 2015; Tiefenbeck et al., 2019).

Such feedback mechanisms have been incorporated in diverse behavioural interventions aimed at the optimisation of energy use, for instance in smart meters which are expected to contribute to a reduction in energy consumption (Bundesministerium für Wirtschaft und Klimaschutz, n.d.). One example of such a smart meter is the HanzeBox that has been invented by HanzeNet, a Dutch start-up (HanzeNet, n.d.). In contrast to traditional energy meters, smart meters possess an advanced ability of “measuring, collecting, analysing and controlling energy usage data” (Sun et al., 2016; p. 3) thereby offering a more detailed and transparent insight into energy consumption and associated behavioural patterns (Bundesministerium für Wirtschaft und Klimaschutz, n.d.).

In the development and design process of such a smart meter and its feedback features, the usage of a holistic approach is deemed as crucial to optimise the user experience and increase its effectiveness (Munkácsy, 2013). Therefore, besides technical aspects in smart metering, psychological factors should also be considered, for which research has come up with a variety of ideas to enhance individual motivation for efficient energy use. One prominent theory which seems worthwhile in this regard is goal framing theory (Lindenberg & Steg, 2007), being concerned with different representations of information (goal framing) and the impact of goal salience on behaviour. Closely connected to goal frames and ultimately behaviour seem to be individual value orientations which are essential in the guidance of one’s behaviour and the evaluation of one’s own and other’s behaviours. To understand the influence of these two variables on PEB better, the following research question is posed: *How do goal frames and value orientations influence the motivation to engage in PEB?*

Theoretical framework

Goal Framing Theory

Goal framing theory holds that people process information differently, depending on their presentation (i.e., framing), which subsequently influences an individual’s evaluation of that situation and their behaviour (Lindenberg & Steg, 2007). Within goal framing theory, a goal is defined as a “cognitive representation of a desired state” (Fatoki, 2022; p. 1622) influencing behaviour. Upon activation through certain information, a goal consists of a “motive and an activated knowledge structure” (Lindenberg & Steg, 2007; p.118). For example, a goal might be to save money (desired state) that is made salient by presenting the individual with financial benefits of energy reduction (activation through framing) which might subsequently lead a person to reduce shower time (behavioural influence).

Three goal frames are described within goal framing theory: Hedonic, gain (sometimes also called monetary) and normative goal frames. A hedonic goal implies that the individual aims for an improvement of how they feel. Consequently, factors like emotions and affect are highly influential on the salience of this goal (e.g., Finucane et al., 2000; Pfister & Böhm, 1992; Rozin et al., 1999). Thus, to make a hedonic goal frame in the environmental context most influential on the motivation to engage in PEB, the presented information should stress the pleasure and positive emotions that might be evoked by pro-environmental acts, as a study by Tang et al. (2020) confirms. Contrarily, a gain goal frame is connected to sub-goals concerning personal resource benefits, e.g., monetary savings. Thus, stressing these advantages is utterly important when using this goal frame. Lastly, the normative goal frame deals with the appropriateness of behaviour, i.e., what one ought to do which might, for example, be highlighted by social norms (Lindenberg & Steg, 2007). Studies have shown a positive correlation between normative goal frame and environmentally friendly behaviours. In Sweden, for instance, the use of normative goal frames was more effective than other goal frames in influencing the intention to buy an electric car (Rezvani et al., 2018). Other studies confirm the effectiveness of a normative goal frame on PEB's (Chakraborty et al., 2017; Steinhorst et al., 2015; Tang et al., 2020).

Hedonic, gain, and normative goal frames have been shown to *not* be mutually exclusive, i.e., multiple goals might be active and influential at a time. However, there usually is one dominant goal that prevails in a situation (Lindenberg & Steg, 2007).

Value Orientation

A variable possibly influencing the effectiveness of goal frames on PEB are individual values (i.e., value orientations), as suggested by research (e.g., Stern et al., 2000; Steg et al., 2014). Although value orientation is not consistently defined in literature, there are five characteristics recurring in most definitions. Values are described as “concepts or beliefs” (Schwartz & Bilsky, 1987; p. 551) that guide individual's behaviour and decision-making process, they make individuals aim for a certain end state, are not situation-specific, help to select and/or evaluate behaviours and situations, and are not equally important and thus ordered (Schwartz & Bilsky, 1987). Research in value orientation has been mainly based on the work by Rokeach (1973) and the theory of basic values (Schwartz, 1992, 1994) which proposes 10 basic human values in total. Hence, value orientation refers to the personal

overall set of values which are paramount for an individual's behaviour and evaluation of situations.

More specifically, for the environmental context, egoistic, altruistic, biospheric (de Groot & Steg, 2007), and hedonic value orientations (Steg et al., 2014) have been suggested as promising predictors for PEB. Individuals holding strong egoistic value orientations, ascribe a high importance to social power and wealth; those holding a strong altruistic value orientation, to equality and helpfulness; those holding a strong biospheric value orientation, to preventing pollution, and protecting the environment (de Groot & Steg, 2008); and those holding a strong hedonic value orientation to improvement of one's feelings and the minimisation of effort (Steg et al., 2014).

Relationship between Goal Framing Theory and Value Orientation

Although research has investigated the influence of goal frames and value orientations on PEB separately, research on their joint effect has not resulted in clear findings. Considering value orientation's stability over time (Schwartz & Bilsky, 1987) and goal frames situation-specificity (Lindenberg & Steg, 2007), it appears more likely that value orientations affect the relationship between goal frames and PEB and not vice versa. This is supported by research focusing on the role of value orientations on the relationship between goal frames and PEB.

Research investigating this relationship has found inconclusive results. A study by Brandsma and Blasch (2019), for instance, used four value orientations (egoistic, altruistic, and biospheric, hedonic) to investigate their effectiveness on goal frames and eventually on PEB. Participants received different kinds of feedback about their energy consumption representing the three goal frames (gain, hedonic, normative) three times per week and were additionally asked to set a goal for energy reduction. The results showed that individuals with a strong egoistic value orientation were only partly more likely to engage in energy reduction when presented with a gain goal frame, as their motivation for energy reduction depended on the presentation of a request for a high conservation goal prior to the feedback. Furthermore, in the study participants with a strong hedonic value orientation were not significantly influenced in their motivation by any of the goal frames. On the other hand, individuals with strong altruistic values showed more motivation to reduce energy consumption when presented with feedback in monetary and kWh terms representing the gain and hedonic goal frame.

These mixed findings are confirmed by other research as well. According to Canto et al. (2022), value orientations exert a great influence on the salience of goal frames, meaning that the greater the importance of certain values, the more responsive it will make an individual to some goal frames. For instance, one might assume that an individual holding strong egoistic values feels more addressed by a gain goal frame, while individuals with strong hedonic values feel rather addressed by a hedonic goal frame. On the other hand, some research also shows that values do not bear any predictive power for the relationship between goal frames and PEB. In a review it was concluded that values, next to attitudes and beliefs, are no reliable predictors of behavioural change regarding energy consumption or conservation (Frederiks et al., 2015). They argue that oftentimes third variables moderate the relationship between values and PEB, as for example, problem awareness or knowledge (Frederiks et al., 2015).

Current Study

This explanatory research will focus on the influence of two different goal frames (hedonic and gain goal frame) on the motivation to engage in PEB. The normative goal frame will not be included, as it has already been investigated more profoundly (e.g., Van Der Werff et al., 2018). Since the influence of value orientation on the relationship between goal frames and PEB seems to be somewhat unclear, the four value orientations egoistic, altruistic, biospheric, and hedonic will additionally be considered. Furthermore, this research will also explore the moderating effect of the willingness to give up comfort¹.

This might ultimately help to improve and customise feedback about energy consumption. It does not only bear importance on a broader level but also on a more personal one. More clarity in this matter might help to improve smart meters in ways that increase individual motivation to engage in PEB.

Methods

Participants and Design

In this explanatory research an experimental online survey was conducted with a mixed design of 3 (Visualisation: control versus energy versus money) x 2 (Motivation to Engage in PEB: pre versus post) with Egoistic, Altruistic, Biospheric, Hedonic Value

¹ This variable is considered outside of the scope of this research work. It was added due to a request from an external supervisor.

Orientation; and Willingness to Give Up Comfort as moderator variables. Visualisation was included as a between-subject variable, the five moderator variables as within-subject variables, and the Motivation to Engage in PEB as a within-subject variable.

An initial sample of 134 was recruited through convenience sampling via social media, networking of the researcher (120 participants), and through SONA systems (14 participants) for which students could earn partial course credit. Subjects were excluded that did not give consent to participate in the study and those who withdrew their initially given consent at the end of the survey. Furthermore, participants with missing values were deleted. This led to a final sample of 39 participants which consisted of 27 (69.2 %) women and 12 (30.8 %) men with an age span between 18 and 64 years ($M = 23.26$, $SD = 5.43$). Furthermore, 26 Germans (66.7%), four Dutch (10.3%), four Mexicans (10.3%), and five persons with another nationality (12.8%) participated. For a more detailed description of demographics, see Appendix A.

Procedure

The online experiment was advertised through SONA systems, social media, and networking. Possible participants were told that the study would aim for an improvement of the interface of the HanzeBox. A provided link or QR code let the participants proceed to the online survey in Qualtrics (Appendix B).

First, participants were informed about all important aspects and requirements for partaking in the study. Subsequently, participants could choose to give consent or withdraw from the study. Choosing not to give consent, led the survey directly to end, thanking the participant for their participation in the study.

Next, participants had to answer several questions about demographic data, the HanzeBox, Egoistic Value Orientation, Altruistic Value Orientation, Biospheric Value Orientation, Hedonic Value Orientation, and Motivation to Engage in PEB. A short explanation and some examples about PEB were given to make the questions about PEB more comprehensive.

Before then being presented with one of the three visualisations, which depended on the condition, participants were asked to imagine themselves in a situation in which they were about to check their energy consumption of the last two weeks via the web portal of the

HanzeBox. Furthermore, they were asked to picture themselves living alone. Consequently, one of the three visualisations, depending on the condition, was presented to participants.

Then, before again being asked about their Motivation to Engage in PEB, participants were reminded that they had just been presented with the visualisation and that they should not let themselves be influenced by previous answers they had given to similar questions. This was done to prevent participants from thinking that the same questions about their Motivation to Engage in PEB as before the visualisation were used and to prevent participants to pay less attention.

Next, participants were asked about how they think the presented visualisation would influence their Motivation to Engage in PEB, and their Willingness to Give up Comfort for the sake of PEB. Afterwards, the survey showed both the energy and money visualisations and let participants indicate their preference on different variables (Understanding, Liking, Helpfulness) and asked in an open question for an elaboration of the participant's opinion.

Finally, they were asked if any additional persons from the same household participated, debriefed, and thanked for partaking. Since participants were deceived about the real purpose of the study in the beginning, they were now informed about the real purpose of the study, i.e., the influence of goal frames on the motivation to behave pro-environmentally while investigating the influence of value orientations on that relationship. If desired, they had the option to withdraw their initially given consent.

Measures

Demographic Data and HanzeBox

Nine questions about demographic data were posed to the participant. These concerned the Age, Gender, Nationality, Education, Employment Status, Marital Status, House Type, and the Total Number of Persons Living with the Participant (including the participant). As participants were told that the survey would assess them on their opinions about the smart meter HanzeBox, two questions about the participant's familiarity with the HanzeBox and the reason for the purchase of the HanzeBox, if possessing one, were asked.

Motivation

The Motivation to Engage in PEB was taken as a pre and post measurement; prior and post to being exposed to the visualisation. Nineteen items from the Intrinsic Motivation

Inventory (IMI) were used (Deci et al., 1994) and presented in a matrix in the pre and post measurement (Appendix C).

Although originally being comprised of seven subscales, for the purpose of this study only the three subscales interest/enjoyment (seven items), effort/importance (five items), and value/usefulness (seven items) were used and slightly altered (i.e., in most cases “activity” was replaced by “PEB’s”). The participants had to rate the statements (e.g., “PEB’s are enjoyable for me”, “I think PEB’s are a boring activity”) on a 5-point Likert scale, ranging from 1 to 5 (1 = *strongly disagree* to 5 = *strongly agree*). Additionally, the option *not applicable* was included to account for participants who would consider themselves to not engage in PEB at all. All items were presented in a randomised order. In the post measurement, the statements were basically the same as in the pre measurement, only slightly changed (e.g., “PEB’s would be enjoyable for me.” and “I would try very hard on PEB’s”).

Reliability testing resulted in one good and one excellent Cronbach's α of .88 and .92 for the pre measurement and the post measurement, respectively. For the pre measurement a Guttman's λ^2 of .9 and for the post measurement a Guttman's λ of .93 were computed. Due to the high degree of reliability, no items were deleted. The respective 19 items of the pre measurement were combined and averaged into the variable Pre Motivation and the respective 19 items of the post measurement were combined and averaged into the variable Post Motivation. The variable Delta Motivation was constructed by computing the difference between Post Motivation and Pre Motivation.

Value Orientation

For the Egoistic, Altruistic, Biospheric, and Hedonic Value Orientation, the survey included a matrix with 16 items. The items were presented in a randomised order. The respective items can be found in Appendix D.

For the Egoistic Value Orientation, five items, and for the Altruistic and Biospheric Value Orientation, four items each were used (e.g., “Social power: control over others, dominance”, “Helpful: working for the welfare of others”). Items were devised by De Groot and Steg (2008) who based them on the theory of basic values by Schwartz (1992, 1994). The items were measured on a 5-point Likert scale ranging from 1 to 5 (1 = *very unimportant* to 5 = *very important*).

For Egoistic Value Orientation a poor Cronbach's α of .57 and a Guttman's λ of .6 were computed. The item wealth was dropped and raised the Cronbach's α to a questionable value of .63 and the Guttman's λ to a value of .64. For Altruistic Value Orientation, a poor Cronbach's α of .58 and Guttman's λ of .59 were computed and no item was dropped. For Biospheric Value Orientation a good Cronbach's α of .82 and a Guttman's λ of .83 were found, no items were dropped.

To assess participant's Hedonic Value Orientation, three items from Steg et al. (2014) were used. These were based on Schwartz (1992, 1994) and assessed participants on a 5-point Likert-scale ranging from 1 to 5 (1 = *very unimportant* to 5 = *very important*) on their Hedonic Value Orientation. Two of these items were "Enjoying life: enjoying food, sex, leisure, etc., enjoying life's pleasures" and "Pleasure: gratification of desires, having fun".

Although dropping the item self-indulgent could have led to a questionable Cronbach's α of .69 (as opposed to a Cronbach's α of .63), all items were kept as this construct was only measured with three items. A Guttman's λ of .65 was computed.

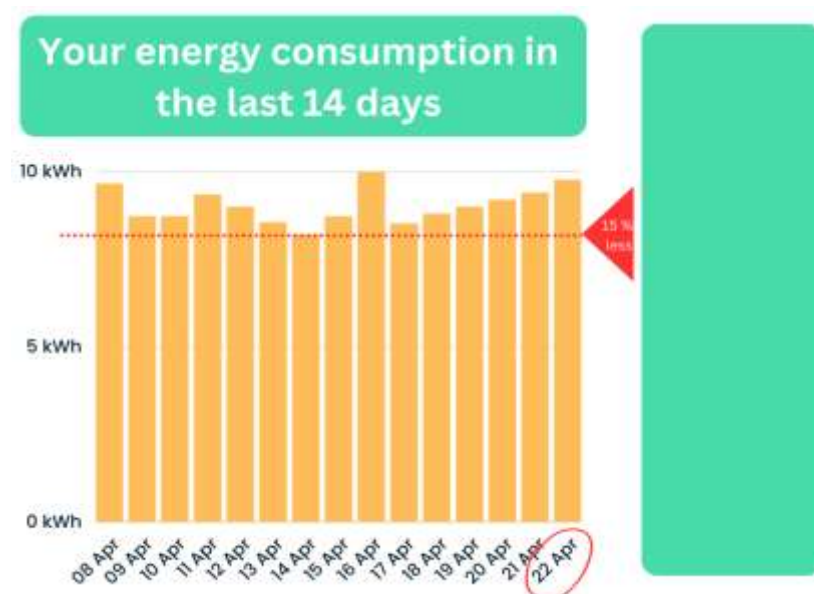
Visualisation

The variable Visualisation depicted the visualisation participants saw and hence also the condition participants were assigned to with the values 0 (control visualisation), 1 (energy visualisation), and 2 (money visualisation). For data analysis, two dummy variables (Energy Visualisation and Money Visualisation) were created, based on the variable Visualisation with the values 0 (control visualisation) and 1 (energy visualisation, money visualisation).

For each condition (control, energy, money) a respective visualisation was designed. For the energy and money condition, a combination of a graph and a summary was used, whereas for the control condition only a graph was presented (see Table 1 and Figure 1). All three graphs were created using the online tool canv.com.

Figure 1

Visualisation about Energy Consumption



Note. This visualisation was presented in the energy condition. For the money condition this visualisation was used with monetary terms on the y-axis. Respective summaries (see Table 1) were inserted into the green box on the right. In the control condition this visualisation was presented without a dashed red line, a red arrow on the right, and a summary in the green box.

Table 1

Experimental Conditions and their Respective Summaries

Condition	Respective summary
Control	-
Energy	<p>Yesterday (22 Apr) you consumed 9.77 kWh energy.</p> <p>Based on your household characteristics you could be able to spend at least 15 % less kWh next week (<i>red arrow</i>). This would translate into savings of 1.46 kWh.</p>
Money	<p>Yesterday (22 Apr) you spent 4.7€ on energy consumption.</p> <p>Based on your household characteristics you could be able to spend at least 15 % less money next week (<i>red arrow</i>). This would translate into savings of 70.5 cents.</p>

Note. The respective summary was added into the green box on the right of the bar chart (Figure 1). For the control condition no box nor a summary was presented to participants.

To design realistic visualisations, data of the latest energy prices and the energy consumption per person were used (Stromspeigel, n.d.; Bundesverband der Energie und Wasserwirtschaft, 2023). According to these sources, the normal energy consumption of a single person household lays between 1,400 kWh and 4,500 kWh per year and the energy price equalled 48.12 cents in March 2023. Based on this, graphs and summaries were created.

The bar chart displayed the last 14 days with the corresponding energy consumption (see Figure 1 and Table 1). The participant could see that during the last six days the energy consumption increased. A red arrow on the right side of the bar of the last day (April 22nd) indicated the energy consumption level corresponding to 15% less energy usage in comparison to April 22nd. An additional dashed line was added to the bar chart indirectly indicating that on April 14th 15% less energy had already been consumed. This was thought to convince the participant that consuming 15% less energy is a feasible goal and to enhance self-efficacy.

In essence, the only difference between the graphs in the three conditions was how the information was framed on the y-axis of the graph and in the summary on the right: in the money condition, the unit used on the y-axis was € and in the energy and control condition it was kWh. Using €-terms in the money condition was considered to make a gain goal salient as resources should be highlighted while using kWh terms was thought to contribute to the salience of a hedonic goal frame since people might feel better about saving energy. Furthermore, only in the money and energy condition, an arrow, a dashed line, and a summary on the right side of the graph were given. The respective summary informed about the energy consumption of the previous day (April 22nd) and theoretical savings in monetary or energy terms and about a possible energy reduction of 15%. The control condition only presented a graph to the participant without any feedback in terms of an arrow, a dashed line, or a summary.

Additional Questions

For a short evaluation about the presented visualisation, four additional questions concerning the Liking, the Easiness to Understand the Visualisation, the Helpfulness, and general feedback were asked, e.g., “How much did you like the visualisation you saw?” and “How helpful do you consider this visualisation for receiving feedback on your energy consumption?”. For the first three questions a 5-point Likert-scale ranging from 1 to 5 (1 = *dislike a great deal* to 5 = *like a great deal* (liking), 1 = *extremely difficult* to 5 = *extremely*

easy (easiness to understand), and 1 = *very unhelpful* to 5 = *very helpful* (helpfulness)) was used. The fourth question was an open question asking people to elaborate on their opinion about the visualisation. All questions were self-constructed with an unacceptable Cronbach's α of .44 and a Guttman's λ 2 of .46.

Willingness to Give up Comfort

To measure the Willingness to Give up Comfort for the sake of PEB, five self-constructed items (e.g., “I am willing to give up comfort for the sake of PEB’s”, “I do not want to give up comfort for the sake of PEB’s”) were posed and had to be answered on a 5-point Likert scale, ranging from 1 to 5 (1 = *strongly disagree* to 5 = *strongly agree*). Item `comfort_3` was dropped and increased the poor Cronbach's α of .56 to a questionable Cronbach's α of .69. A Guttman's λ 2 of .73 was computed. See Appendix E for all items.

Comparison Visualisations

To explore participant's preferences of the two visualisations (energy and money), a matrix presented questions concerning Liking, Helpfulness, Understanding, and Motivation. Participants could indicate on a 2-point scale (1 = *energy visualisation* and 2 = *money visualisation*), their preference for the different aspects. The items had a good Cronbach's α of .44 and a Guttman's λ of .46. See Appendix F.

An additional open question was asked for a more profound elaboration for participant's preferences and ideas for improvements (Appendix G).

Data Analysis

After data collection, the data with an initial sample of 136 participants was downloaded from Qualtrics, checked and pre-processed. The entire data analysis was done in R Studio (version 4.3.0).

For the pre-processing, several variables were renamed and values were recoded and variables that were not needed for the further analyses were deleted. Subsequently, all participants that did not give consent, withdrew it at the end of the survey, or had other missing values, were excluded from the data set. Since some items were negatively termed, they were reversed (see Appendix C and Appendix E). The data set was revised for any striking responses (e.g., selecting the same answers for all items on both pre and post motivations scales), none had to be removed.

Based on reliability testing, several variables were constructed. These were Pre Motivation, Post Motivation, Delta Motivation, Egoistic Value Orientation, Altruistic Value Orientation, Biospheric Value Orientation, Hedonic Value Orientation, Comfort, Visualisation, Energy Visualisation, and Money Visualisation.

For a better overview, descriptive statistics were computed, including standard deviations, means, and correlation coefficients. For the dummy variables (i.e., Gender, Energy Visualisation, and Money Visualisation) point-biserial correlation coefficients, for the ordinal variable Education a Spearman's rank correlation coefficient, and for the rest of the variables (i.e., Age, Persons Household, Motivation, Egoistic Value Orientation, Altruistic Value Orientation, Biospheric Value Orientation, Hedonic Value Orientation, Willingness to Give up Comfort) Pearson's correlation coefficients were used to compute the respective correlations between continuous variables.

Next, a manipulation check and parametric assumptions tests were conducted. For the manipulation check, the energy condition and the control condition, and the money condition and the control condition were compared in a *t*-test which revealed that the manipulations did not work as intended, since the test was non-significant (energy condition: $p = .73$, money condition: $p = .87$). For the assumptions of normality, homoscedasticity, independence, and linearity histograms, box plots, residual plots, and Shapiro-Wilk tests (Appendix I) were used and showed that several assumptions had been violated. Despite violations, linear regression models were used due to the robust nature of linear regression models.

In total 10 linear regression models were run to investigate the effect of Energy Visualisation and Money Visualisations (independent variables) on the Motivation to Engage in PEB (dependent variable) while also taking Egoistic Value Orientation, Altruistic Value Orientation, Biospheric Value Orientation, Hedonic Value Orientation, and Willingness to Give up Comfort as moderator variables into account.

Results

Correlations

Computing the correlations between variables revealed some significant correlations (see Table 2). Firstly, results showed a negative correlation between Age and Hedonic Value Orientation ($r = -.43$), suggesting that with increasing age, an individual's hedonic value orientation decreases. Furthermore, Gender and the Willingness to Give up Comfort showed a

significant correlation ($r_{pb} = .51$), indicating that women tend to be more willing to give up comfort for the sake of PEB's than men. Moreover, a significant correlation between Persons Living in a Household and Egoistic Value Orientation was found ($r = .37$) which shows that with an increasing number of persons individuals live with, the strength of their egoistic value orientation slightly enhances. The Motivation to Engage in PEB's and Hedonic Value Orientation did also show a slight significant correlation ($r = .34$) which indicates that individuals holding stronger hedonic values tend to be slightly more motivated to engage in PEB. Further, Egoistic Value Orientation and Altruistic Value Orientation did also significantly correlate ($r = .37$), showing that as egoistic value orientation in individuals rises, altruistic value orientation does so too. Lastly, Altruistic Value Orientation and Biospheric Value Orientation resulted in a strong significant correlation ($r = .62$), meaning that the stronger an individual's altruistic value orientation, the stronger is also their biospheric value orientation.

Table 2

Means, Standard Deviations, and Correlations between Variables and their Descriptives.

Variables	1	2	3	4	5	6	7	8	9	10	11	12
M	23.26	-	2.23	3.61	-	-	0.39	3.33	4.47	4.31	4.45	3.21
SD	5.43	-	0.54	3.35	-	-	0.34	0.57	0.38	0.51	0.49	0.63
1.Age	1											
2.Gender ^a	-.19	1										
3.Education	.20	-	1									
4.Persons Household	-.12	-	-.26	1								
5.Energy Visualisation ^b	-.19	-	-.07	.03	1							
6.Money Visualisation ^b	.07	-	.20	.18	-	1						
7.Motivation	-.15	.15	.05	-.06	.11	-.15	1					
8.Egoistic Orientation	.03	.07	.13	.39	.18	.13	.11	1				
9.Altruistic Orientation	.08	.21	.24	.31	-.07	.01	-.01	.37	1			
10.Biospheric Orientation	.21	.05	.14	.02	.17	-.05	-.02	.15	.62	1		
11.Hedonic Orientation	-.43	.28	.08	-.23	.26	-.20	.34	.00	.08	.09	1	
12.Comfort	-.06	.51	-.21	-.14	-.05	-.03	-.12	-.28	.05	.25	.18	1

Note. N = 39. Significant p-values ($p < .05$) are in bold

^a 0 = male and 1 female. ^b 0 = control condition 1 = energy/money condition.

Linear Regression Analyses

For an overview of all coefficients and values see Appendix H.

Egoistic Value Orientation

The analysis revealed that the model including Energy Visualisation and Egoistic Value Orientation as independent variables did not significantly affect the Motivation to Engage in PEB's, as $F(3, 35) = 0.30, p = .83$. Neither Egoistic Value Orientation ($b = 0.09, t = 0.66, p = .51$), nor Energy Visualisation ($b = 0.34, t = 0.46, p = .65$), nor the interaction between Energy Visualisation and Egoistic Value Orientation ($b = -0.08, t = -0.37, p = .72$) did significantly impact the Motivation to Engage in PEB.

Furthermore, using Money Visualisation and Egoistic Value Orientation as predictor variables indicated that the overall model did not yield a significant effect on the Motivation to Engage in PEB, since $F(3, 35) = 0.48, p = .70$. The three predictors Egoistic Orientation ($b = 0.09, t = 0.74, p = .47$), Money Visualisation ($b = -0.07, t = 0.08, p = .93$), and the interaction between Money Visualisation and Egoistic Orientation ($b = -0.02, t = -0.6, p = .95$) did not show any significant effects either.

This suggests that both visualisations (energy, money) did not influence an individual's motivation to engage in PEB and that this relationship is not dependent on egoistic value orientation either.

Altruistic Value Orientation

Conducting an analysis using Energy Visualisation and Altruistic Value Orientation as the Independent Variables resulted in a non-significant effect of the overall model, since $F(3, 35) = 0.38, p = .77$. Moreover, Energy Visualisation ($b = 1.26, t = 0.89, p = .38$), Altruistic Orientation ($b = 0.11, t = 0.53, p = .60$), and the Interaction between Energy Visualisation and Altruistic Orientation did not bear any significant effects on the Motivation to Engage in PEB.

Including Money Visualisation and Altruistic Value Orientation as independent variables showed insignificant effects of the overall model, as $F(3, 35) = 0.26, p = .85$. Further, Money Visualisation ($b = -0.06, t = -0.03, p = .97$), Altruistic Value Orientation ($b = -0.004, t = -0.02, p = .98$), and the interaction between Money Visualisation and Altruistic Value Orientation ($b = -0.01, t = -0.03, p = .97$) did not significantly predict the Motivation to Engage in PEB.

Hence, results show that Energy and Money Visualisation did not exert an influence on the Motivation to Engage in PEB, while this relationship was not dependent on Altruistic Value Orientation either.

Biospheric Value Orientation

Analysing the effect of Energy Visualisation and Biospheric Value Orientation on the Motivation to Engage in PEB, resulted in no significant overall effect of the model, as $F(3, 35) = 0.42, p = .74$. No significant effect of Energy Visualisation ($b = 1.05, t = 0.94, p = .36$), Biospheric Value Orientation ($b = 0.04, t = 0.28, p = .78$), or the Interaction between Energy Visualisation and Biospheric Value Orientation ($b = -0.22, t = -0.86, p = .39$) on the Motivation to engage in PEB was found.

Moreover, the results indicated that the overall model including Money Visualisation and Biospheric Value Orientation as independent variables did not significantly influence the Motivation to Engage in PEB's, since $F(3, 35) = 1.53, p = .22$. No significant effect of Biospheric Value Orientation on the Motivation to Engage in PEB was found ($b = -0.17, t = -1.25, p = .22$). However, a significant effect of Money Visualisation ($b = -2.04, t = -2.02, p = .05, 95\% \text{ CI } [-4.09, 0.01]$) and a marginally significant interaction effect of Money Visualisation and Biospheric Value Orientation on the Motivation to Engage in PEB was found ($b = 0.45, t = 1.93, p = .06, 95\% \text{ CI } [-0.02, 0.92]$).

This means that an individual's motivation to engage in PEB is not influenced by energy visualisation and that this relationship is not impacted by biospheric value orientation either. However, the effect of money visualisation might depend on the strength of biospheric values, as the marginally significant effect suggests here. Nonetheless, this needs to be interpreted with caution, since the effect is only marginally significant.

Hedonic Value Orientation

The overall model including Energy Visualisation and Hedonic Value Orientation as Independent Variables did not indicate significant effects, as $F(3, 35) = 1.68, p = .19$. Moreover, the predictors Energy Condition ($b = -0.66, t = -0.97, p = .60$), Hedonic Value Orientation ($b = 0.21, t = 1.51, p = .14$), and the Interaction between Energy Visualisation and Hedonic Value Orientation ($b = 0.15, t = 0.54, p = .59$) did not show significant effects on the Motivation to Engage in PEB.

For the model including Money Visualisation and Hedonic Value Orientation as Independent Variables, no significant effect of the overall model was found, since $F(3, 35) = 1.65, p = .20$. Money Visualisation ($b = 0.02, t = 0.01, p = .99$), Hedonic Value Orientation ($b = 0.24, t = 1.87, p = .07$), and the Interaction between Money Visualisation and Hedonic Value Orientation ($b = -0.02, t = -0.06, p = .95$) did not yield significant effects either.

Thus, neither the energy nor the money visualisation influenced motivation to engage in PEB. This was also not dependent on an individual's hedonic value orientation.

Willingness to Give up Comfort

Results showed that the overall model including Energy Visualisation and Willingness to Give up Comfort as Independent Variable did not significantly impact the Motivation to Engage in PEB, as $F(3, 35) = 0.40, p = .75$. Further, Energy Visualisation ($b = 0.46, t = 0.65, p = .52$), the Willingness to Give up Comfort ($b = -0.03, t = -0.32, p = .75$), and the interaction between Energy Visualisation and the Willingness to Give up Comfort ($b = -0.12, t = -0.55, p = .59$) indicated insignificant effects on the Motivation to Engage in PEB.

For the model including Money Visualisation and Willingness to Give up Comfort as independent variables, the overall model did not show significant effects, as $F(3, 35) = 0.62, p = .61$. Moreover, Money Visualisation ($b = -0.58, t = -0.89, p = .38$), Willingness to Give up Comfort ($b = -0.11, t = -1.01, p = .32$), and the interaction between Money Visualisation and Willingness to Give up Comfort ($b = 0.15, t = 0.72, p = .47$) did not significantly affect the Motivation to Engage in PEB's.

Hence, both energy and money visualisation, were not effective in changing an individual's motivation to behave more environmentally friendly. The willingness to give up comfort did not moderate this relationship either.

Additional Analyses

Simple Slope Analysis

To examine the marginally significant interaction effect of Biospheric Value Orientation and Money Visualisation on Motivation to Engage in PEB, a simple slope analysis was attempted to conduct. Due to an unknown error in RStudio, however, slope coefficients could not be obtained. Nonetheless, a plot with Money Visualisation on the x-axis and the predicted values for the Motivation to Engage in PEB (Figure 2) might point out that

increasing levels of Biospheric Value Orientation positively influence the Motivation to Engage in PEB when being presented with a Money Visualisation.

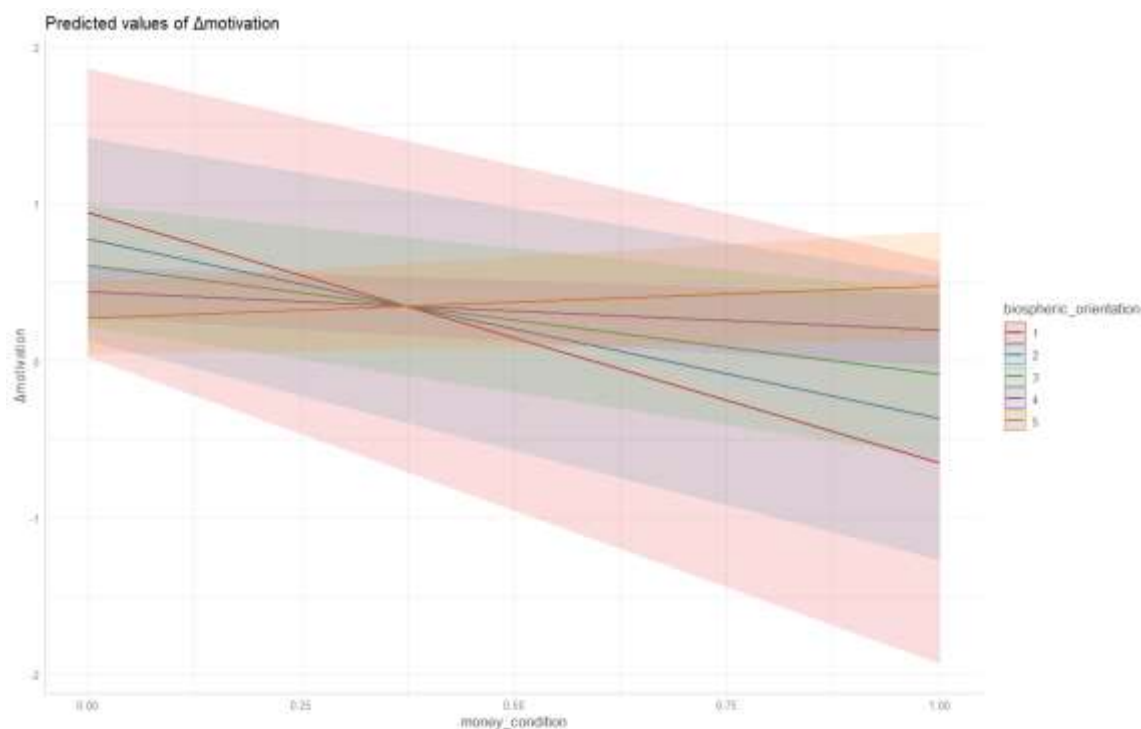
Comparison Visualisations

To obtain a better understanding of participant's opinions about the two visualisations, frequencies and open questions of the online survey were examined. These showed that the majority of the participants preferred the money visualisation over the energy visualisation in a variety of aspects. For participants, the money visualisation was easier to understand, more helpful, and more motivating. Concrete values can be found in Appendix F.

Most participants referred in the open questions (Appendix G) to the abstract nature of the energy visualisation and that it was harder for them to understand the savings in kWh terms. Energy savings being framed in monetary units did not, according to participant's comments, require any prior knowledge about energy prices and normal energy consumption as compared to the framing in kWh terms.

Figure 2

Predicted Values for Independent Variable Motivation to Engage in PEB for Different Levels of Biospheric Value Orientation.



Comparison Visualisations

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Discussion and Conclusion

The aim of this exploratory research was to examine the impact of the hedonic and gain goal frame on the motivation to engage in PEB while exploring the moderating effects of egoistic, altruistic, biospheric, and hedonic value orientation; and the willingness to give up comfort. The goal frames were represented as two visualisations (energy visualisation and money visualisation).

Findings

The research question *How do goal frames and value orientations influence the motivation to engage in pro-environmental behaviour?* can thus be answered as follows: Neither the energy visualisation nor the money visualisation did influence an individual's motivation to engage in PEB. In this research, the energy visualisation was meant to embody the hedonic goal frame whereas the money visualisation was meant to represent the gain goal frame.

Furthermore, the moderator variables (willingness to give up comfort; egoistic, altruistic, biospheric, and hedonic value orientations) used in this research (egoistic, altruistic, biospheric, hedonic) did not exert any impact on the relationship between goal frames and the motivation to engage in PEB. The only exception was the joint influence of money visualisation (gain goal frame) and biospheric value orientation, suggesting that individuals holding higher biospheric value orientations are more likely to feel slightly more motivated to engage in PEB when being presented with a money visualisation about their energy

consumption. However, this has to be interpreted tentatively, as the effect was only marginally significant.

Goal Frame Theory

Initial expectations were that highlighting money savings would activate knowledge structures associated with financial benefits leading to a heightened motivation to engage in PEB as this would indirectly foster greater money savings (gain goal frame) and that presenting information in kWh would motivate individuals to engage in PEB as a result of an association with environmental protection and a subsequent better feeling (hedonic goal frame). However, in the present study, differently termed information about energy consumption did not seem to shape an individual's perception and processing of a given situation and to make certain goals and knowledge structures more salient.

These outcomes partially contradict other research which found effects of goal frames on the motivation to behave environmentally friendly. For instance, Tang et al. (2019) investigated the effect of the three goal frames (hedonic, gain, normative) on green consumption behaviour (GCB) and concluded that the hedonic and normative goal frame positively impacted individual's GCB whereas no significant effect of gain goal frame on GCB was found. Yet, Griskevicius et al. (2010) found a positive effect of gain goals on PEB by the usage of status motives which caused an association thereof with green consumption in individuals.

The non-significant effects of goal frames in this study might be explained by several factors. The data used for the summaries and the visualisations about energy consumption was based on average data rather than on personal, real data, leading to the assumption that participants possibly did not feel addressed and responsible enough through the graphs and summaries. It was not possible to deduce and reflect on actual behaviours they had engaged in prior to the feedback that might have led to the levels of energy consumption. Even though participants were invited to imagine themselves in the situation, this might have not sufficed. This may explain why no shift in motivation as opposed to prior to the study could be observed.

Moreover, the visualisations in this paper might have not represented perfectly the two goal frames (hedonic and gain goal frame) and have thus perhaps not made the respective goals sufficiently salient. The energy visualisation displayed energy consumption in terms of

kWh which was initially considered a hedonic goal frame as this, it was argued, would address emotions, and motivate participants to feel better as through saving kWh they could exert some positive environmental impact. Nonetheless, the hedonic goal frame implies that individuals are sensitive to those aspects that *immediately* make them feel better. Hence, could one consider this visualisation to be a suitable representation of the hedonic frame, does it really lead to an improvement of how one feels? Or should it better be regarded as a representation of a gain goal frame as kWh could also be regarded as a resource that wants to be maintained or improved?

Value Orientation

Another factor considered as influential on the relationship between goal frames and the motivation to engage in PEB were egoistic, altruistic, biospheric (de Groot & Steg, 2007), and hedonic value orientation (Steg et al., 2014). Assuming that holding certain stronger values makes it simpler to achieve salience of goals and influence individual's motivation to engage in PEB did not prove to be correct here. The finding that individuals felt slightly more motivated to engage in PEB when being presented with a gain goal frame when holding strong biospheric values contradicts prior research that has only found a positive moderating effect of biospheric value orientation on the motivation to engage in PEB when individuals were presented with a hedonic goal frame rather than a gain goal frame (Brandsma & Blasch, 2019). Intuitively, it also appears more reasonable to assume that individuals scoring high on biospheric values are more responsive to feedback in kWh terms than in € terms since a strong biospheric value orientation indicates that individuals are concerned about environmental matters, as for example preventing pollution (de Groot & Steg, 2008).

Hence, value orientation as a third variable seems to be of little importance and added value in the context of goal frame's effectiveness on acting environmentally friendly. This is contrary to claims made by various research papers (Bolderdijk, 2013; Brandsma & Blasch, 2019; Canto et al., 2022) which found effects of different value orientations on the effectiveness of goal frames on the PEB. Rather, the results of this research appear to be in line with Frederiks et al. (2015), discovering that value orientations do not serve as good predictors of PEB. Additional, yet unknown factors may be more valuable in predicting the effectiveness of goal frames on PEB. Tang et al. (2019), for example, discovered that perceived risk and lifestyle had mediating effects on GCB. In their research, perceived risk negatively mediated the relationship between hedonic/normative goal frame and GCB, while

lifestyle positively mediated the relationship between hedonic/normative goal frames and GCB. This is in accordance with the participant's comments in this research about the visualisation, mentioning the necessary knowledge to interpret the visualisation in kWh terms. For lay people it appears that the understanding of energy consumption in € terms is easier to understand than in kWh, as participants also indicated in this research. Hence, one third variable could possibly be knowledge about energy consumption. This might ultimately have different effects on the motivation to engage in PEB.

Limitations and Strengths

Several limitations in this study should be mentioned. Surprisingly, the reliability of the measurement for egoistic, altruistic, and hedonic value orientations was relatively low ($\alpha = .63, .59, .63$, respectively), indicating a low internal consistency. This contradicts de Groot and Steg's (2007) findings using egoistic and altruistic value orientations to predict PEB, who reported a good Cronbach's α of .83 for both value orientations. The low reliability might be explained by the relatively small sample size ($n = 39$) and relatively few items (three to five items) per value orientation.

Further, the manipulation checks showed that the manipulation with the different visualisations did not work as intended. This might be due to several factors, including the imperfect representation of goal frames and the data used for the visualisations. Using real data and stressing aspects like financial benefits more, might have contributed to the salience of goal frames and to consequently observe changes between conditions.

An additional limitation is the operationalisation of the motivation to engage in PEB which was measured with self-report and not with actual behavioural measures (e.g., measuring energy consumption before and after being presented with one of the visualisations). Participants might behave differently in real life, as it is also acknowledged by Peattie (2010): The presence or absence of the motivation for environmentally friendly behaviours is not always put into action by individuals.

Besides the limitations, one strength of this research that is worth mentioning, is the reliability of motivation. Using the three subscales interest/enjoyment, effort/importance, and value/usefulness from the Intrinsic Motivation Inventory resulted in a good and an excellent Cronbach's α of .88 and .92.

Implications and Directions for Future Research

With regard to the marginally significant effect of money visualisation (gain goal frame) and biospheric value orientation on PEB, it might be interesting to investigate this finding further to obtain more clarity. It seems illogical that persons with a high biospheric value orientation are more motivated to engage in PEB when presented with a gain goal frame.

Furthermore, future research might attempt to enhance reliability when delving into value orientations since analyses revealed relatively low reliability values for the value orientations. Including more items for the measurement of value orientation and obtaining a larger sample might contribute to the reliability of such research.

Moreover, elucidating the impact of other variables, like knowledge or perceived risk and lifestyle, different disciplines could eventually consider these and improve visual feedback incorporate in smart meters, like the HanzeBox, to be as effective and motivating as possible. As mentioned above, perceived risk or knowledge might be worthwhile investigating further. For example, one might speculate that individuals having a high risk perception of climate change feel more motivated to engage in PEB when presenting with a hedonic goal frame that highlights possible impacts of energy reduction on the environment.

Conclusion

In conclusion, this research has yielded inconclusive findings about the influence of value orientation on the effectiveness of goal frames and on the motivation to engage in PEB. This might be due to the study's limitations or yet unknown variables. Further research should dive deeper into other variables possibly influencing this relationship. In doing so, visual feedback's effectiveness could be enhanced by taken those factors into account. Making visual feedback more motivating with regard to PEB would contribute to a reduction in GHG emissions. Although this effect might not be tremendous, and other measures are required to obtain certain environmental goals (e.g., the 2030 climate and energy framework), tackling energy reduction in the residential sector with visual feedback poses one possibility to influence our environment for the better and to act *now*, starting in our homes.

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Appendices

Appendix A: Extended Demographics

Table A1

Extended Demographics of the Sample

Baseline characteristics	Energy condition		Money condition		Control condition		Full sample	
	n	%	n	%	n	%	n	%
Gender								
Female	8	20.51	9	23.08	10	25.64	27	69.23
Male	4	10.26	3	7.69	5	12.82	12	30.77
Nationality								
German	7	17.95	5	12.82	14	35.90	26	66.67
Dutch	1	2.56	3	7.69	0	0	4	10.26
Mexican	3	7.69	1	2.56	0	0	4	10.26
Other	1	2.56	3	7.69	1	2.56	5	12.82
Education								
Middle school	0	0	0	0	1	2.56	1	2.56
High school	10	25.64	8	20.51	11	28.21	29	74.36
Bachelor	2	5.13	3	7.69	3	7.69	8	20.51
PHd	0	0	1	2.56	0	0	1	2.56
Employment								
Student	8	20.51	10	25.64	9	23.08	27	69.23
Part-time employed	1	2.56	1	2.56	0	0	2	5.13
Full-time employed	2	5.13	1	2.56	4	10.26	7	17.95
Other	1	2.56	0	0	1	2.56	2	5.13
Prefer not to say	0	0	0	0	1	2.56	1	2.56
Marital status								
Single	9	23.08	6	15.38	6	15.38	21	53.85
Relationship, not living together	3	7.69	4	10.26	5	12.82	12	30.77
Married	0	0	1	2.56	1	2.56	2	5.13
Living with a partner	0	0	1	2.56	3	7.69	4	10.26
House type								
Student house	0	0	5	12.82	5	12.82	10	25.64
Flat	9	23.08	4	10.26	6	15.38	19	48.72
Detached house	6	15.38	3	7.69	1	2.56	10	25.64

Note. N = 39

Appendix B: Survey

Informed Consent: Informative Text and Question about Informed Consent

Dear participant,
thank you for deciding to take part in this study!

With this research we aim for an improvement of the interface of the smart meter HanzeBox that has been developed by a Dutch start-up from Deventer. As opposed to traditional meters, smart meters in general provide you with detailed information on your consumption of energy, water, gas etc.

For an improvement, we would like to know your opinion. We will present a design to you and ask you a variety of questions. This survey is part of a Bachelor's Thesis of the University of Twente.

Some important points before getting started with the survey

- For this research it is important that you understand a basic level of English as the survey will be completely in English.
- It is important that you are at least 18 years old.
- Participation is completely voluntary and you can withdraw from the study at any time without having to give a reason for doing so or having to fear any negative consequences.
- Participation is anonymous which means that the researcher will not be able to identify an individual participant.
- Your data will be handled and stored confidentially so that it will not be possible to trace the given information back to you. Data will be archived so that it can be used for further research and learning.

If any questions arise, you can contact the student l.m.huilmann@student.utwente.nl or the supervisor p.w.devries@utwente.nl

Thank you for participating in this study.

I consent to take part in this study after having read and understood the information.

I do NOT consent to take part in this study after having read and understood the information.

Demographic Data

DD-Info

First, you will be asked some simple questions about demographic data on the next pages.

DD-2: Age

How old are you? 18-24, 23-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85 and over

DD-3: Gender

What is your gender? Male, Female, Non-binary/third gender, prefer not to say

DD-4: Nationality

What nationality do you have? Dutch, German, Mexican, Other

DD-5: Highest Level of Education

What is your highest level of education you have **completed**? less than middle school, middle school (such as MBO, MTS, MEAO or Haupt- or Realschule), High school degree (such as HAVO, VWO, HBS or Gymnasium/Berufsschule/Berufskolleg), Bachelor's Degree, Master's Degree, PhD or similar/higher level of degree, other

DD-6: Employment Status

What does best describe your current employment status? Retired, Student, employed full-time, Employed part-time, Unable to work, Prefer not to say, Other

DD-7: Marital Status

What does best describe your current marital status? Single (never married), Living with a partner Married, Separated, Widowed, Divorced, Prefer not to say, In a relationship, but not living together, Other

DD-8: House Type

What type house do you currently live in? Terraced house (Reihenhaus/rijtjeshuis), Detached house (freistehendes Haus/vrijstaand huis), Flat (Wohnung/appartement), Student house (Studentenhaus/studentenhuis), Other, please specify:

DD-9: Persons Household

Including yourself, with how many persons do you currently live?



HanzeBox

HB-Info

The next questions are aimed at gaining a better impression of your familiarity and use of the smart meter "HanzeBox".

HB-1: Familiarity HanzeBox

How familiar are you with the HanzeBox? Not familiar at all, Slightly familiar, Moderately familiar, Very familiar, Extremely familiar

HB-2: Reason for purchase (not displayed when HB-1 was answered with "not familiar at all")

Why did you purchase the HanzeBox?

Personal values

PV-Info

To get to know you better, we will ask you about your personal values in the following section. Values are concepts or beliefs that guide you in your daily life. On the next page you will find a list of values. Please think thoroughly about these values and how important they are to you. Then indicate for each value the importance they have in your life.

PV-1: Value orientation

Please indicate now the importance these values have for you.

	Very unimportant	Somewhat unimportant	Neither unimportant nor important	Somewhat important	Very important
Social power: control over others, dominance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wealth: material possessions, money	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Authority: the right to lead or to command	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Influential: having an impact on people and events	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ambition: hard-working, aspiring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Equality: equal opportunity for all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A world at peace: free of war and conflict	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Social justice: correcting injustice, care for the weak	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Helpful: working for the welfare of others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Preventing pollution: protecting natural resources	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Respecting the earth: harmony with other species	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Unity with nature: fitting into nature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Protecting the environment: preserving nature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pleasure: gratification of desires, having fun	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Enjoying life: enjoying food, sex, leisure etc., enjoying life's pleasures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Self-indulgent: doing pleasant things	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I do not try very hard to do well in PEB's.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I try very hard to do well in PEB's.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is important to me to do well in PEB's.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I do not put much energy into PEB's.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I believe engaging in PEB's can be of some value to me (if so, please specify)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I think engaging in PEB's is not useful for saving money.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I think engaging in PEB's is important because it is good for the environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am willing to engage more often in PEB's because it has some value to me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Visualisation Info

V-Info-1

Now you will be presented with a visualisation. It is important that you carefully read these instructions.

Imagine that you live in a one-person household (alone, without any other person) and you want to check your energy consumption of the last 14 days. You do so by accessing the web portal of the smart meter HanzeBox and find the visualisation/design on the next page.

It is important that you take a close look at the visualisation and take as much time as you need. Once you go to the next question after the visualisation, you cannot go back to the visualisation.

V-Info-2

To summarise, please imagine and do the following things:

Imagine that..

- you live in a one-person household
- you want to obtain feedback about your energy consumption

And don't forget to..

-take a close look at the visualisation

-take as much time as needed

Additional Questions

AQ-1: Liking of Visualisation

How much did you like the visualisation you saw?

Dislike a great deal, Dislike somewhat, Neither like nor dislike, Like somewhat, Like a great deal

AQ-2: Easiness to Understand Visualisation

How easy was it for you to understand the presented visualisation?

Extremely difficult, Somewhat difficult, Neither easy nor difficult, Somewhat easy, Extremely easy

AQ-3: Helpfulness Visualisation

How helpful do you consider this visualisation for receiving feedback on your energy consumption?

Very unhelpful, Somewhat unhelpful, Neither helpful nor unhelpful, Somewhat helpful, Very helpful

AQ-4: Open Question about Evaluation of Visualisation

Please elaborate on why you (did) not like the graph and what was (not) easy for you to understand. If you have any additional remarks, you can also add them here.

PostM-Info

We will now ask you again about your motivation to engage in pro-environmental behaviours. Remember that you have just been presented with a visualisation about energy consumption. So, imagine how you would feel when always receiving this form of feedback.

It is possible that similar questions were already asked before. Please do **NOT** let your answers be influenced by previous answers. Instead, answer the questions according to how you feel in this very moment.

PEB's are more important to me than my comfort.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When deciding what to do, I do not weigh comfort and PEB's first	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Comfort is more important for me than engaging in PEB's.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Comparison visualisation

CV-1: Explanation text about visualisations

There is one visualisation that you did not see. We will now show you both of them and would like to know your opinion about them. Below you can find both visualisations. Please observe them closely. Below you will be asked several questions about them

CV-2: Preference for visualisation

Which of the two visualisations did you like better? Please elaborate below why.

	Visualisation 1	Visualisation 2
Which option did you understand better?	<input type="radio"/>	<input type="radio"/>
Which option did you like more?	<input type="radio"/>	<input type="radio"/>
Which option would motivate you more?	<input type="radio"/>	<input type="radio"/>
Which option do you consider more helpful?	<input type="radio"/>	<input type="radio"/>

CV-3: Open question to elaborate

Why did you like Visualisation 1 or 2 more? Please elaborate.

Do you have any additional ideas on how to improve the visualisations?

End of survey

ES-1

Were there any other persons who live with you that participated in this research? Yes, No, I don't know

ES-2

In the beginning, you were told that this survey is aimed at improving the interface of the smart meter HanzeBox. This was only partly true, as the main goal of the study was to investigate the influence of different goal frames on the motivation to engage in pro-environmental behaviours (PEB's).

Each person that participated in this survey was presented with a different visualisation. Some received feedback in € - terms and some in kWh - terms. Yet, another group did not receive any feedback at all, only a graph with the energy consumption of the last 14 days. All the questions before and after the visualisation were asked to determine the influence of the visualisation on motivation to engage in PEB's and to investigate the correlation between individual characteristics and the motivation to engage in PEB's.

In the beginning you were also asked to consent to this study. Now, after being disclosed about the real purpose of the study, you might wish to withdraw your initial consent you gave us. This would mean that your data would not be used for this research. Of course, withdrawing your initial consent does not bear any negative consequences for you. Please indicate below how you would like to proceed.

I consent for the use of my data once more, I wish to withdraw my initial consent

Appendix C: Items Intrinsic Motivation Inventory

Table C1

Items for Motivation to Engage in PEB with their Respective Item Stem

Subscale	Item label	Item stem
Interest and enjoyment	Interest_enjoyment_1pre	I enjoy engaging in PEB's very much
	Interest_enjoyment_1post	If I received feedback in the visual form that has been presented to me, I would enjoy engaging in PEB's
	Interest_enjoyment_2pre	PEB's are fun to do.
	Interest_enjoyment_2post	If I received feedback in the visual form that has been presented to me, it would be fun to engage in PEB's.
	Interest_enjoyment_3pre (*)	I think PEB's are a boring activity.
	Interest_enjoyment_3post (*)	If I received feedback in the visual form that has been presented to me, I would consider PEB's a boring activity.
	Interest_enjoyment_4pre (*)	PEB's do not hold my attention at all.
	Interest_enjoyment_4post (*)	If I received feedback in the visual form that has been presented to me, PEB's would not hold my attention at all.
	Interest_enjoyment_5pre	I would describe PEB's as very interesting.
	Interest_enjoyment_5post	If I received feedback in the visual form that has been presented to me, I would consider PEB's as interesting.
	Interest_enjoyment_6pre	I think PEB's are quite enjoyable.
	Interest_enjoyment_6post	If I received feedback in the visual form that has been presented to me, PEB's would be quite enjoyable for me.
	Interest_enjoyment_7pre	When I engage in PEB's I think (while engaging in them) about how much I enjoy them.
	Interest_enjoyment_7post	If I received feedback in the visual form that has been presented to me, I would think about how much I enjoyed it while engaging in PEB's.
Effort and importance	Effort_importance_1pre	I put a lot of effort into PEB's
	Effort_importance_1post	If I received feedback in the visual form that has been presented to me, I would put a lot of effort into PEB's.
	Effort_importance_2pre (*)	I do not try very hard to do well in PEB.
	Effort_importance_2post (*)	If I received feedback in the visual form that has been presented to me, I would not try very hard to do well in PEB's.
	Effort_importance_3pre	I try very hard to do well in PEB's
	Effort_importance_3post	If I received feedback in the visual form that has been presented to me, I would try very hard on PEB's.
	Effort_importance_4pre	It is important to me to do well in PEB's
	Effort_importance_4post	If I received feedback in the visual form that has been presented to me, it would be important to me to do well in PEB's

	Effort_importance_5pre (*)	I do not put much energy into PEB's
	Effort_importance_5post (*)	If I received feedback in the visual form that has been presented to me, I would not put much energy into PEB's.
Value and usefulness	Value_usefulness_1pre	I believe engaging in PEB's can be of some value to me.
	Value_usefulness_1post	If I received feedback in the visual form that has been presented to me, I would believe engaging in PEB's would be of some value to me
	Value_usefulness_2pre (*)	I think engaging in PEB's is not useful for saving money.(
	Value_usefulness_2post (*)	If I received feedback in the visual form that has been presented to me, I would not think engaging in PEB's is useful for saving money.(R)
	Value_usefulness_3pre	I think engaging in PEB's is important because it is good for the environment.
	Value_usefulness_3post	If I received feedback in the visual form that has been presented to me, I would think engaging in PEB's is important because it is good for the environment
	Value_usefulness_4pre	I am willing to engage more often in PEB's because it has some value to me.
	Value_usefulness_4post	If I received feedback in the visual form that has been presented to me, I would be more willing to engage more often in PEB's because it would have some value to me
	Value_usefulness_5pre	I think engaging in PEB's could help me to do something good for the environment.
	Value_usefulness_5post	If I received feedback in the visual form that has been presented to me, I would think engaging in PEB's could help me to do something good for the environment.
	Value_usefulness_6pre	I believe engaging in PEB's is beneficial to me for saving money
	Value_usefulness_6post	If I received feedback in the visual form that has been presented to me, I would believe engaging in PEB's is beneficial to me for saving money
	Value_usefulness_7pre (*)	I do not think engaging in PEB's is an important activity because of the environment.
	Value_usefulness_7post (*)	If I received feedback in the visual form that has been presented to me, I would not think engaging in PEB's is an important activity because of the environment.

Note. (*) indicates reverse items.

Appendix D: Value Orientation Items

Table D1

Items for Value Orientations with their Respective Item Stem

Value orientation	Item label	Item stem
Egoistic value orientation	Social_power	Social power: control over others, dominance
	Wealth (*)	Wealth: material, possessions, money
	Authority	Authority: the right to lead or to command
	Influential	Influential: having an impact on people and events
	Ambition	Ambition: hard-working, aspiring
Altruistic value orientation	Equality	Equality: equal opportunity for all
	World_at_peace	World at peace: free of war and conflict
	Social_justice	Social justice: correcting injustice, care for the weak
	Helpful	Helpful: working for the welfare of others
Biospheric value orientation	Preventing_pollution	Preventing pollution: protecting natural resources
	Respecting_the_earth	Respecting the earth: harmony with other species
	Unity_with_nature	Unity with nature: fitting into nature
	Protecting_the_environment	Protecting the environment: preserving nature
Hedonic value orientation	Pleasure	Pleasure: gratification of desires, having fun
	Enjoying_life	Enjoying life: enjoying food, sex, leisure etc., enjoying life's pleasures
	Self_indulgent	Self-indulgent: doing pleasant things

Note. (*) indicated deleted item.

Appendix E: Items Willingness to Give up Comfort

Table E1

Items for Willingness to Give up Comfort with their Respective Item Stem

Item label	Item stem
Comfort_1	I am willing to give up comfort for the sake of PEB's.
Comfort_2 (*)	I do not want to give up comfort for the sake of PEB's.
Comfort_3	I weigh PEB's against my comfort and then decide what to do.
Comfort_4	PEB's are more important to me than my comfort.
Comfort_5 (*)	When deciding what to do, I do not weigh comfort and PEB's first
Comfort_6	Comfort is more important for me than engaging in PEB's.

Note. (*) indicates reverse items.

Appendix F: Comparison Visualisations

Table F1

Preferred Visualisation on Variables Liking, Understanding, Helpfulness, Motivation

	Energy Visualisation		Money Visualisation	
	n	%	n	%
Liking	8	20.51	31	79.49
Understanding	6	15.38	33	84.62
Helpfulness	7	17.95	32	82.05
Motivation	6	15.38	33	84.62

Note. N = 39.

Appendix G: Comments on Visualisations

“money instead of kwh”

"I can translate the money spent on the work I had to do to obtained, in that way, I can see how the energy consumes the money I work Hard to obtain "

"I think the second Visualisation is more tangible for an \"otto Normalverbraucher\" who doesn't understand the Parameter kW.\nBecause of fluctuations and value of money it's to easy thinking.\nIt's only for the moment valide and the course isn't meaningful in later evaluations, but for a moneysaver it's useful.\nYou have to deale with and analyse the first visualisation and I don't think many people are motivated to do so.\n\n "

"I liked Visualisation 2 more because it was a concept that I was able to grasp and directly apply to my circumstances as I do not normally work with kwh”

"visualisation 2 can help you more to save money”

"For Visualisation 2 one does not need to know current energy prices, which is very convenient."

"I prefered visualisation 2 because it tells you how much money you save or have to save in order to motivate you more to use less electricity, because the first one tells you about how much you used/saved kw/h, being this measure something that you might not care much, since it's not easy to understand how important it is, but when it comes to money, then it became important."

"Make it easy to understand for everyone"

"Saving 70.5€ is not very much money for me. I think a more rough visualisation would be better, maybe a weekly overview. Maybe there are days where I am only a short period of time at home and on other days I do my household and consume more energy. So some differences in energy consumption are explainable and it wouldn't be possible to save 15% of energy/money as written. I would simply think you do not have any idea of the reality. It's nice to see the chart and get an overview of my energy consumption but the real world is more complex."

"I cannot dimension quite well the value of a kWh but the value of money I can and it shows hoy much money I can save in a month, it is easier to make a decision to save or not that amount of money than the amount of kWh"

"In Visualisation 2 you can see how much money you can save "

"I have more idea what € means"

“I liked Visualisation 2 more because you know exactly what amount of money I spent in 14 days"

"Because I do not really have an idea about kWh and how much it costs, what it does to the environment etc. "

"I think it is easier to conceptualize energy consumption in terms of monetary value than in terms of kWh."

"People only care about the money they're spending on energy, not thw kWh."

"I like it more because I am not familiar enough with kWh to understand on a deeper level what the difference would mean, but Euro ist very familiar for me and like this I could try to lose less money every day "

"Money"

"You measure energy in kWh, not in euro. Visualisation 1 can be used with one sentence added which translates kWh to euros."

"I liked visualisation 2 more, as it clearly shows how much money can be saved by reducing energy. For me that way it is easier to measure than in kWh, as I do not know a lot about the measurement of it."

"Visualization 1 was better because it showed how much kWh I use instead of the money I need to pay. Visualisation 2 on the other hand is good because it shows you how much money you spend due to your consumption."

"Visualization 1 makes me want to understand my energy consumption more rather than option 2. But option 2 motivates me more because of my savings. maybe these two aspects can be combined into one visualisation"

"Sometimes, we see how much energy we consume but we cannot really understand it except if we have some knowledge and can do the link between money and energy. One of the main numbers that are universally understandable is money. When I learn that I consumed ~3/4 kWh more than another day I don't really realize but if I see that I "lost" 1€ compared to another day I will instantly realize what I lost and wouldn't lose it again (we usually like to keep our money)"

"For me understanding the price in euros is easier than understanding kWh, because I don't know much about it."

"money aspect. Mittelwert erstellen und vergleich zum rest der bevölkerung"

"I think it is difficult for me, what it means to consume a specific amount of energy because i have not dealt with it before in my life. But what i do know is, what i can buy with almost 5 €. \n\nIf there was a table which tells you, how much tons of CO2 are produced by procucing the energy you consume or how many trees there have to be to outway my energy consumption or some other points which relay to the environment, so the impact for the nature becomes clearer, I maybe would like the first visualation as much as the second one. \nBecause then i would understand the numbers better."

"It lays in bare the cost implication of my energy consumption "

"I liked the Visualisation 2 more, because it gives me a motivation to save money AND do something for the environment at the same time."

Appendix H:
Linear Regression Analyses

Table H1*Linear Regression Analyses on Ten Models*

	<i>b</i>	SE	<i>t</i>	<i>p</i>	LLCI	ULCI
Model 1						
Energy Visualisation	0.34	0.74	0.46	.65	-1.16	1.83
Egoistic VO	0.09	0.14	0.66	.51	-0.19	0.37
Interaction Energy Visualisation x Egoistic VO	-0.08	0.21	-0.37	.72	-0.51	0.36
Model 2						
Money Visualisation	-0.07	0.88	-0.08	.93	-1.86	1.71
Egoistic VO	0.09	0.12	0.74	.47	-0.15	0.32
Interaction Money Visualisation x Egoistic VO	-0.02	0.26	-0.06	.95	-0.54	0.50
Model 3						
Energy Visualisation	1.26	1.41	0.89	.38	-1.61	4.13
Altruistic VO	0.11	0.20	0.53	.60	-0.31	0.52
Interaction Energy Visualisation x Altruistic VO	-0.26	0.32	-0.83	.41	-0.90	0.38
Model 4						
Money Visualisation	-0.06	1.55	-0.04	.97	-3.21	3.09
Altruistic VO	-0.01	0.18	-0.02	.98	-0.38	0.37
Interaction Money Visualisation x Altruistic VO	-0.01	0.35	-0.03	.97	-0.71	0.69
Model 5						
Energy Visualisation	1.05	1.12	0.94	.36	-1.23	3.34
Biospheric VO	0.04	0.14	0.28	.78	-0.24	0.32
Interaction Energy Visualisation x Biospheric VO	-0.22	0.25	-0.86	.39	-0.74	0.30
Model 6						
Money Visualisation	-2.04	1.01	-2.02	.05	-4.09	0.01

Biospheric VO	-0.17	0.14	-1.25	.22	-0.44	0.11
Interaction Money Visualisation x Biospheric VO	0.45	0.23	1.93	.06	-0.02	0.92
Model 7						
Energy Visualisation	-0.66	1.26	-0.53	.60	-3.23	1.90
Hedonic VO	0.21	0.14	1.51	.14	-0.07	0.49
Interaction Energy Visualisation x Hedonic VO	0.15	0.27	0.54	.59	-0.41	0.71
Model 8						
Money Visualisation	0.02	1.38	0.01	.99	-2.78	2.81
Hedonic VO	0.24	0.13	1.87	.07	-0.02	0.50
Interaction Money Visualisation x Hedonic VO	-0.02	0.32	-0.06	.95	-0.66	0.62
Model 9						
Energy Visualisation	0.46	0.71	0.65	.52	-0.98	1.90
Comfort	-0.03	0.11	-0.32	.75	-0.25	0.18
Interaction Energy Visualisation x Comfort	-0.12	0.22	-0.55	.59	-0.56	0.32
Model 10						
Money Visualisation	-0.58	0.66	-0.89	.38	-1.91	0.75
Comfort	-0.11	0.11	-1.01	.32	-0.33	0.11
Interaction Money Visualisation x Comfort	0.15	0.20	0.72	.47	-0.26	0.56

Note. N = 39. VO = Value Orientation. Significant p-values ($p < .05$) are in bold.

Appendix I:

Parametric Assumptions by Value Orientation

Egoistic Value orientation

Figure I1

Assumption of Normality,

Egoistic Value Orientation on Residuals

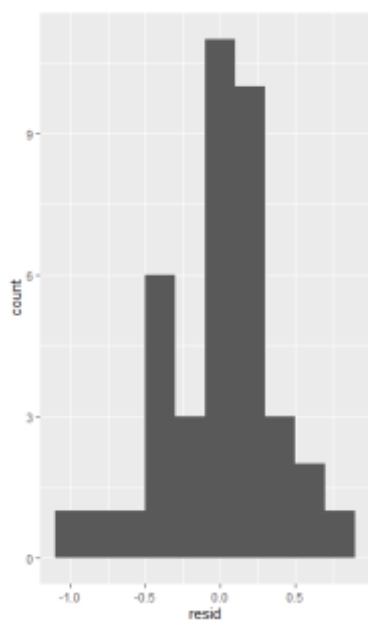


Figure I2

Assumption of Independence,

Residuals Egoistic Value Orientation on Visualisation

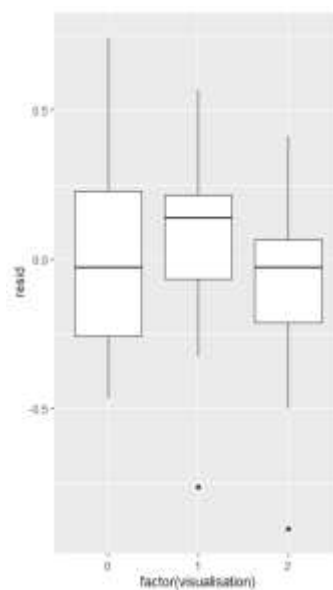


Figure I3

Assumption of Homoscedasticity,

Residuals on Predicted Values

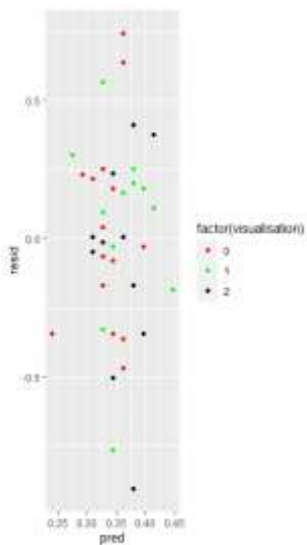
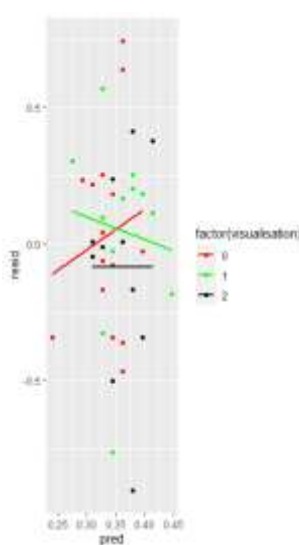


Figure I4

Assumption of Linearity,

Residuals on Predicted Values



Altruistic Value Orientation

Figure I5

Assumption of Normality

Altruistic Value Orientation on Residuals

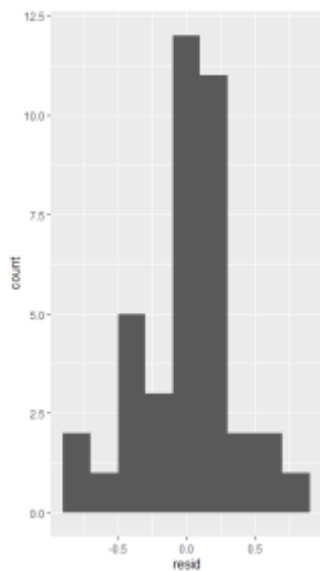


Figure I6

Assumption of Independence,

Residuals on Visualisation

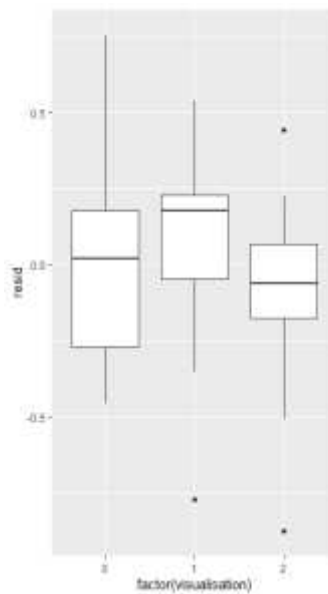


Figure I7

Assumption of Homoscedasticity,

Residuals on Predicted Values

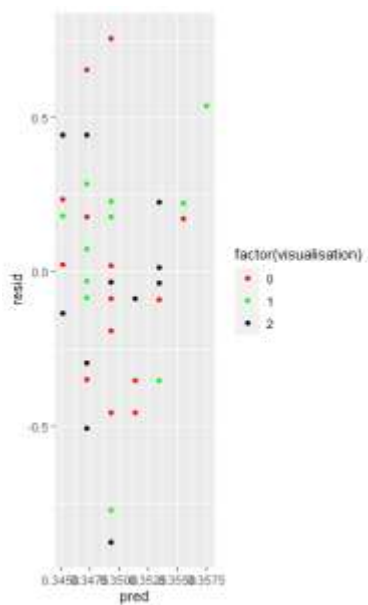
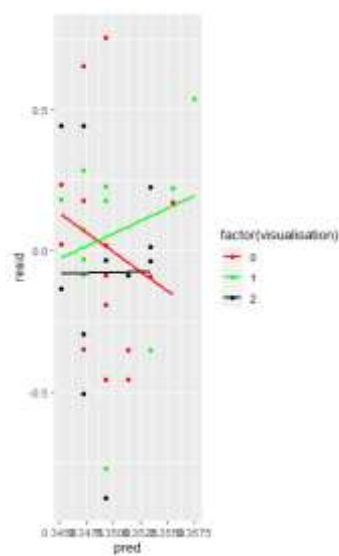


Figure I8

Assumption of Linearity,

Residuals on Predicted Values



Biospheric Value Orientation

Figure I9

Assumption of Normality

Biospheric Value Orientation on Residuals

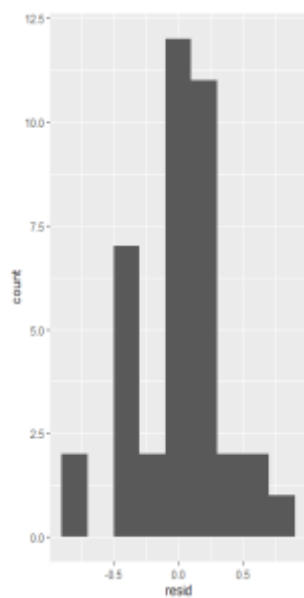


Figure I10

Assumption of Independence,

Residuals on Visualisation

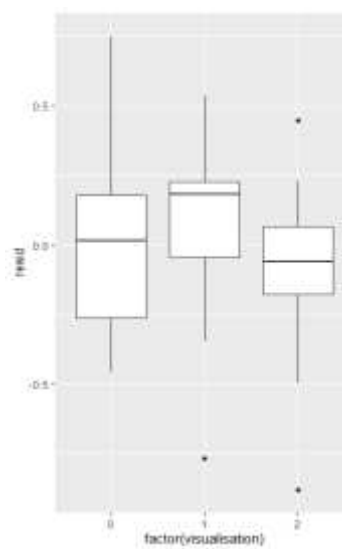


Figure I11

Assumption of Homoscedasticity,

Residuals on Predicted Values

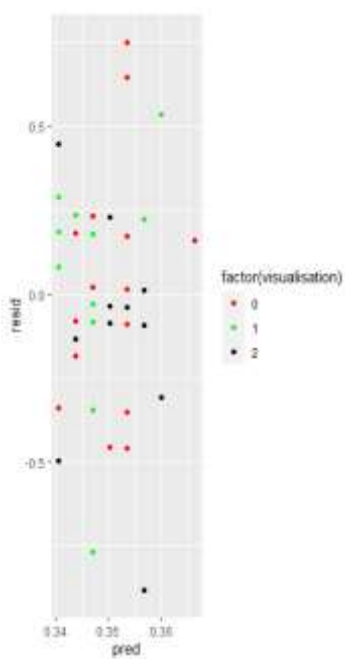
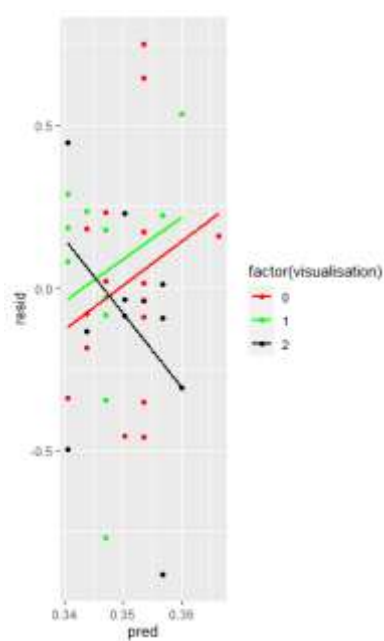


Figure I12

Assumption of Linearity,

Residuals on Predicted Values



Hedonic Value Orientation

Figure I13

Assumption of Normality

Hedonic Value Orientation on Residuals

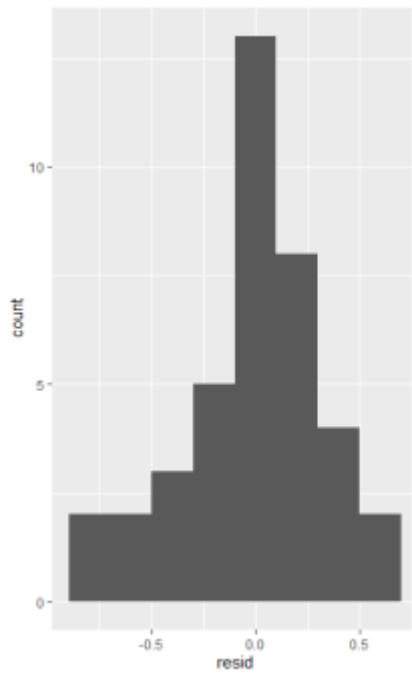


Figure I15

Assumption of Homoscedasticity,

Residuals on Predicted Values

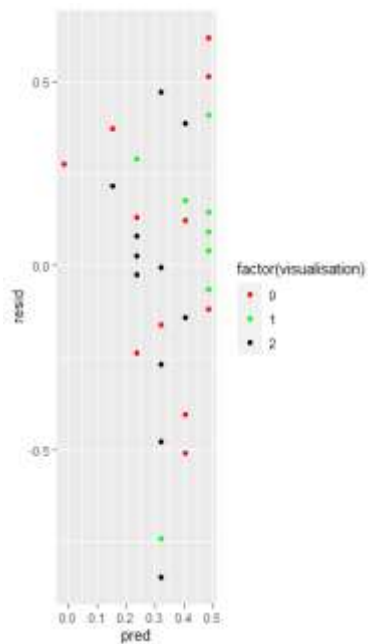


Figure I14

Assumption of Independence,

Residuals on Visualisation

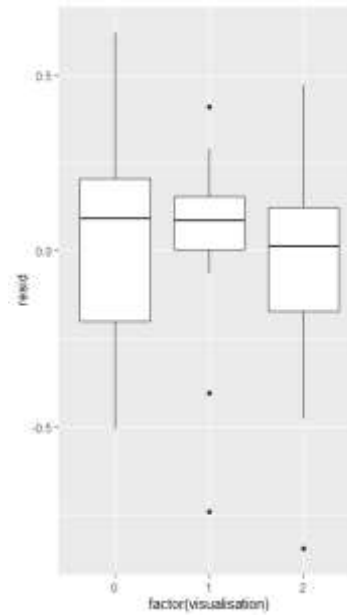
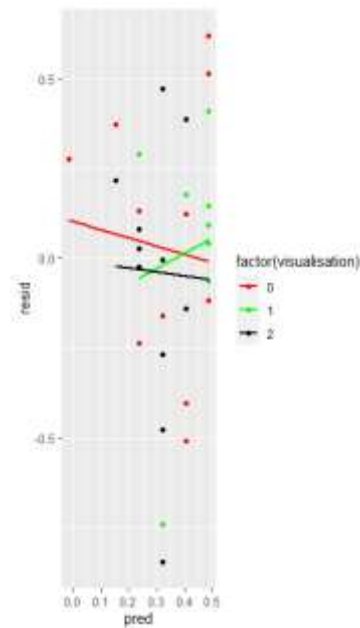


Figure I16

Assumption of Linearity,

Residuals on Predicted Values



Willingness to Give Up Comfort

Figure I17

Assumption of Normality

Comfort on Residuals

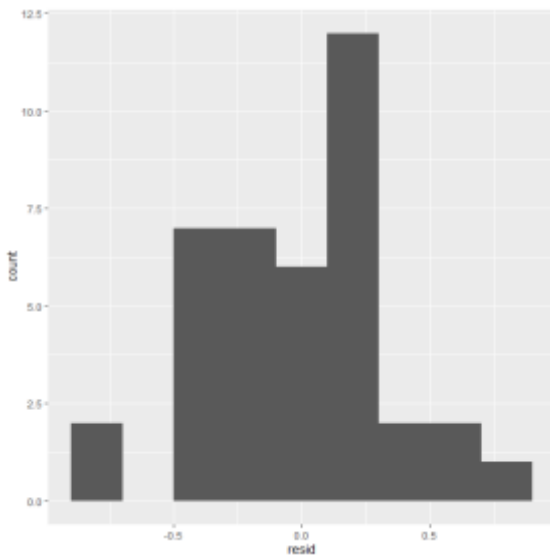


Figure I19

Assumption of Homoscedasticity,

Residuals on Predicted Values

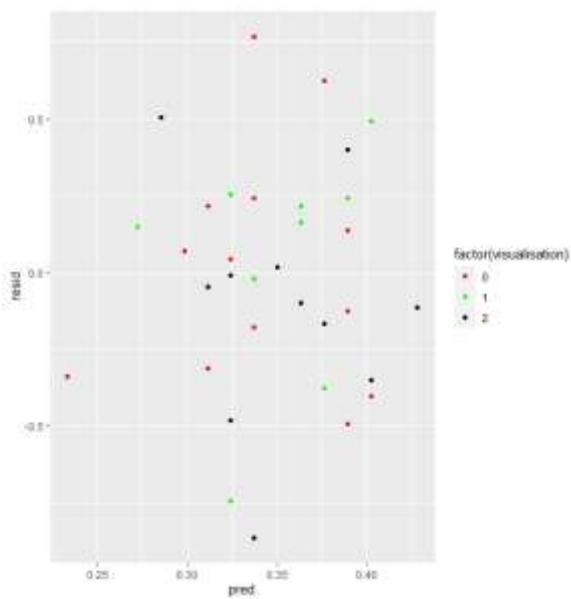


Figure I18

Assumption of Independence,

Residuals on Visualisation

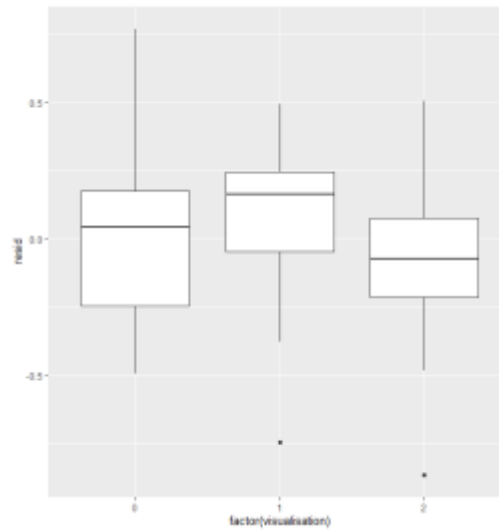


Figure I20

Assumption of Linearity,

Residuals on Predicted Values

