



# Exploring consumer perception of uncoated wooden cladding: a study across three European countries

Geir Wæhler Gustavsen<sup>1</sup> · Philip Bester van Niekerk<sup>2</sup> · Jonas Niklewski<sup>3</sup> · Christian Brischke<sup>4</sup> · Gry Alfredsen<sup>1</sup>

Received: 28 October 2024 / Accepted: 18 February 2025  
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## Abstract

With increased focus on sustainable building materials and the growing popularity of uncoated wooden cladding, understanding consumer acceptance of aesthetic changes becomes crucial for sustainable architectural choices. This study investigated consumer acceptance of uncoated wooden cladding in Norway, Sweden, and Germany, focusing on personality traits and perceptions. Using an online survey with 3112 participants, the study found that preference for uncoated wooden cladding was similar (around 20%) across the three countries, despite differences in the prevalence of wooden cladding. A natural consequence of weathering of wood exposed outdoors is greying of the surface. The survey presented participants with images of uncoated wooden cladding with varying degrees of grey discolouration. Participants rated the acceptability of these claddings based on their preferences. Acceptance of this discolouration differed by country, Norwegians preferred intermediate-coloured panels, Swedes preferred darker panels, and Germans accepted all panels. Personality traits measured using the Big Five personality inventory and socioeconomic factors influenced preferences. In Norway and Sweden, those accepting the discolouration of uncoated wooden cladding included introverts, highly conscientious individuals, young people, females, and those with tertiary education. Additionally, in Norway and Germany, openness to experience was linked to acceptance, while strong emotional control was significant only in Norway. This study underscores the complexity of consumer preferences for uncoated wooden cladding, demonstrating that personality traits, in conjunction with cultural and demographic variables, jointly influence perception. The findings offer valuable insights for architects, builders, and policymakers seeking to advance sustainable construction practices while optimising consumer satisfaction in the housing sector.

## 1 Introduction

To optimise the use of renewable materials, it is crucial to identify the factors that impact decisions during their design and service. In Europe, approaches to life-cycle costing (LCC) of buildings offer sustainable growth through public procurement. This is emphasised by the 2014 EU procurement directive, which mandates contracts be awarded based on the most economically advantageous tender. LCC is crucial in construction sustainability in order to minimise overall costs during a structure's lifespan by taking factors like service life, maintenance, repair, and partial replacement into consideration. Accurate performance forecasting in the design phase reduces resource waste stemming from premature deterioration by facilitating accurate service life planning (SLP). An essential aspect of SLP are limit states in engineering models. These include ultimate limit states (ULS), ensuring structural safety, and serviceability limit states (SLS), ensuring functionality and comfort. While SLS covers deflection and cracking, it generally does not include

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✉ Geir Wæhler Gustavsen  
geir.gustavsen@nibio.no

Philip Bester van Niekerk  
philipbester.niekerk@uni-goettingen.de

Jonas Niklewski  
jonas.niklewski@kstr.lth.se

Christian Brischke  
christian.brischke@thuenen.de

Gry Alfredsen  
gry.alfredsen@nibio.no

<sup>1</sup> Norwegian Institute of Bioeconomy Research, Oslo, Norway

<sup>2</sup> University of Göttingen, Göttingen, Germany

<sup>3</sup> Lund University, Lund, Sweden

<sup>4</sup> Thünen Institute of Wood Research, Hamburg, Germany

aesthetics such as discolouration. However, aesthetics are important to consider as issues like dirt and discolouration often lead to premature replacement of members. Where maintenance procedures are not directly dictated by safety-related compliance limit states, such as in non-loadbearing applications, the limit state preference (e.g. regarding aesthetics) will vary between users and can also be influenced by personality type or other demographic indicators. Therefore, consideration of user preferences for non-loadbearing applications, such as cladding, is essential in LCC calculations. This study will focus on variations in user acceptance of uncoated wooden cladding.

The cladding of a building acts as the initial barrier against precipitation and exposure to other natural elements. Wood as cladding material became more common from sixteenth century onwards (Øvrum 2002). Cladding styles and installation practices varied, reflecting local resources and building traditions. In today's housing construction sector, these variations are not as geographically based as before, but construction style and architectural trends still play a significant role. Historically, a painted cladding and the choice of colour often reflected social status. Unpainted cladding did not have a high social status and was mainly used for utilitarian buildings such as sheds, barns, etc. However, in the last decades, uncoated wooden cladding has gained popularity in private houses and public buildings. According to Hill et al. (2022) the main reasons for this include "much reduced (or zero) maintenance requirements and consequently a reduced environmental impact". However, all uncoated wood eventually turns grey when exposed outdoors.

All materials exposed to weathering undergo degradation processes (Kutz 2005; Hill et al. 2022) and uncoated wooden cladding narrates the tale of the building and its surroundings. The colours of weathered wood include various grey and brown nuances (Hirche 2014). The main factors causing the colour change are photochemical degradation (Feist and Hon 1984; Hon 1991) and discolouring fungi (Zabel and Morell 2020). Areas of surfaces with less moisture exposure exhibit less discolouration than areas with high moisture exposure, and rain events might intensify the discolouration (Zimmer et al. 2017).

It is important to differentiate between the technical service life and the aesthetic service life of a material, i.e., the distinction between the functionality and the appearance of the cladding (Rüther and Time 2015). Aesthetics are a key aspect of architecture, encompassing the combined effects of shape, colour, contrast, material, symmetry, and pattern simplicity (Sandak and Sandak 2017). According to Englund (2013), undesired aesthetic changes are one of the main reasons for replacement of cladding in European countries (together with fungal decay and modernisation). Rüther and Time (2015), list the different factors influencing

technical and aesthetic service life of uncoated wooden cladding: material, design, design of transition (e.g. roof overhang), climate, and exposure time. Weathering processes start as soon as the cladding material is exposed, typically towards the conclusion of the construction phase. The pace and intensity of colour changes of wood depend on these technical and aesthetic service life factors (Gobakken et al. 2008, 2010; Sandak et al. 2015; Sandak and Sandak 2017; Rüther and Time 2015; Forsthuber and Grüll 2018) and even slight variations in meso- and microclimatic conditions will influence the aesthetic appearance of uncoated wooden cladding (Gobakken et al. 2008, 2010; Rüther and Time 2015).

The aesthetic service life is usually dictated by the user and consumer perception will vary depending on background, culture, and country. According to Viholainen et al. (2021) respondents from seven different European countries held diverse perspectives about the physical properties, environmental, social, and economic aspects of using wood as a construction material. They also found that the participants from countries were forming two groups: "*Citizens from Finland, Norway, and Sweden expressed discernibly different perspectives about the acceptability of using wood than did citizens from Austria, Denmark, Germany, and the United Kingdom.*" They identified the strong tradition of building with wood as a likely reason for the grouping of these countries.

Furthermore, in a study by Brischke et al. (2019), the predicted duration of use appeared to depend on the country of origin of the respondents. The average duration of use was predicted highest by Norwegians, followed by Germans and then Slovenians. This difference might be linked to the respondents' expectations based on their experiences in their respective home countries, where Slovenia has the highest climate-induced decay hazard, followed by Germany and then Norway.

Brandt and Shook (2005) concluded that consumers often judge the quality of forest products based on how they look and feel, i.e., their physical, tangible properties and provided an overview of attribute research in forest products. According to Lähtinen et al. (2019), there are two primary consumer categories based on their perceptions of the sustainability benefits of wood: those who prioritise the ecological and physio-technological advantages, and those who value the aesthetic and well-being benefits. Further, the results indicated that emphasis on technological and environmental properties of wood did not show statistically significant effect on respondents' willingness to live in wooden houses. Contrastingly, valuing aesthetics and well-being seem to have a positive and statistically significant impact on preferences towards living houses with wooden structures. In a review study conducted by Harju (2022), the perceived quality of wooden building materials was examined. The results suggest that the perceived quality of wooden construction

materials is shaped by a variety of factors including sensory, social, economic, technical, and sustainability features. Additionally, consumer attitudes towards wooden building materials are influenced by various individual factors such as socio-demographic and psychographic traits and situational circumstances. Further, Harju (2022) stated that the understanding of the perceived quality of wooden building materials remains limited. Previous studies in the wood industry have primarily focused on examining quality indicators associated with the product or supplier, neglecting the influence of consumer characteristics on the perception of quality.

We additionally presume that individual's risk perception may influence the acceptance of uncoated wooden cladding. Evaluation of daily risk perception assesses how individuals perceive and respond to various risks they encounter in their everyday lives. This evaluation considers factors such as personal experiences, cultural influences, and cognitive biases that shape an individual's perception of risk (Keinan and Bereby-Meyer 2012).

Nevertheless, personality includes more than risk-taking behaviour. Personality describes an individual's thoughts, feelings, and behaviour patterns and it develops from birth to adulthood. It consists of various traits that defines how a person reacts in different situations and makes decisions. These traits influence whether someone is cautious or impulsive, emotional or rational, and deliberate or spontaneous in their choices.

Personality traits can be measured using different methods, including the Five Factor Model (Big Five), which identifies five key factors: Extraversion, Agreeableness, Conscientiousness, Emotional Stability, and Openness to Experience. 'Extraversion' involves sociability and assertiveness, so introverts score low on this trait. 'Agreeableness' relates to compassion and trust, with low scores indicating suspicion. 'Conscientiousness' is about organisation and self-discipline. 'Emotional Stability' measures response to stress, and 'Openness to Experience' involves curiosity and creativity. Although these personality traits are not directly observable, they can be inferred through surveys using techniques like Item Response Theory.

Personality traits have been found to affect a variety of everyday choices and habits, such as the consumption of organic food (Gustavsen and Hegnes 2020b), the sweet taste preferences in wine (Saliba et al. 2009), the emotional response elicited by wines (Mora et al. 2019), and environmental concern (Hirsh 2010). It is also widely agreed that individual personality has an influence on aesthetic preferences together with other person-centred factors. Swami and Furnham (2019) reviewed research on the association of personality and visual arts. A key factor is the personality trait Openness to Experience which is highly associated with strong preference for visual arts. This finding is robust and consistent across various studies. Furthermore, Openness

to Experience is positively associated with an appreciation of aesthetic quality (McManus and Furnham 2006) and aesthetic emotions, like pleasure (Fayn et al. 2015). A great number of surveys have been performed on consumers perception of wood materials (e.g. Marchal and Mothe 1994; Nyrud et al. 2008, Roos and Hugosson 2008; Roos and Nyrud 2008; Høibø and Nyrud 2010; Englund 2013; 2015; Sandak et al. 2015; Høibø et al. 2015; Lowell et al. 2015; Lähtinen et al. 2019; Loučanová and Olšáková 2020; Viholainen et al. 2021; Harju 2022; Veholaa et al. 2022; Yu et al. 2023). Previous studies have also explored how personality traits influence environmental attitudes (Hirsh 2010) and preferences for natural materials (Milfont et al. 2012). However, to date, no studies have been performed linking consumers perception of wooden materials with personality traits.

When surveying consumer perceptions, e.g. of wooden cladding, there are several compelling aspects of also including the perspective of personality traits such as those defined by the Big Five model. These include: 1. Individual differences: Personality traits influence how individuals perceive and evaluate products. 2. Cultural variations: Personality traits can vary across cultures, affecting consumer preferences and perceptions. 3. Targeted marketing: Understanding personality traits helps in tailoring marketing strategies to different consumer segments. 4. Predicting behaviour: personality traits are linked to specific consumer behaviours, such as brand loyalty, impulsive buying, and product satisfaction. Hence, incorporating personality traits into the study provides a more comprehensive understanding of consumer perceptions.

The aim of this study was to investigate consumer perception of different weathering phases of an uncoated wooden cladding. Specifically, the research sought to answer the following questions: Do consumers prefer coated or uncoated cladding? How do consumers perceive various stages of weathering of uncoated wooden cladding? What role do personality traits play in shaping these preferences? What role does nationality, i.e. different historic utilisation of wood, play in shaping these preferences? The main contribution of this study is to link consumer tolerance of discolouration of wooden cladding with personality traits.

## 2 Materials and methods

### 2.1 Survey

An online survey was performed in Norway, Sweden, and Germany in July 2023. Respondents between 18 and 89 years of age were randomly recruited across regions in the three countries by IPSOS, a multinational market research and consulting firm (offices in Norway, Sweden and Germany)

with headquarters in Paris, France. The process was as follows: The authors constructed the survey in English with an experienced consultant from IPSOS Norway as a supervisor. The authors translated the survey to Norwegian, Swedish, and German. After that, IPSOS drew approximately 1000 individuals from their panels in Norway, Sweden, and Germany, and made sure that the samples were representative with respect to age, gender, and geographical distribution in the three countries. The respondents were assured that any given information was anonymous and that they could quit the survey at any point. In Norway, 1071 individuals participated, 1030 in Sweden, and 1011 in Germany. The current paper focuses on questions related to acceptance of uncoated wooden cladding.

It is known from previous literature that consumers prefer homogeneous visual properties (Marchal and Mothe 1994; Broman 2000; Nyrud et al. 2008; Høibø and Nyrud 2010; Brischke and Kaudewitz 2015; Gellerich et al. 2017) and the survey thus focused on homogenous colour variations. The participants in the three countries were shown the four pictures in Fig. 1 and given the following background information:

*A wooden cladding can be coated or uncoated. The choice to coat the wood cladding or not is mainly a matter of aesthetic preference. The choice will not significantly affect the durability (longevity) of the wooden cladding itself.*

Then, they were asked how acceptable the surface is. The following background information was given and subsequent question asked with regard to the panels A, B, C, and D (Fig. 1):

*If not treated with any kind of surface finish, all wooden surfaces will eventually turn grey. This is due to weathering and discolouration from fungi, algae, and dust (not decay fungi).*

*How fair or acceptable would you say the following degrees of grey colours of walls as a result of staining/discolouration are?*

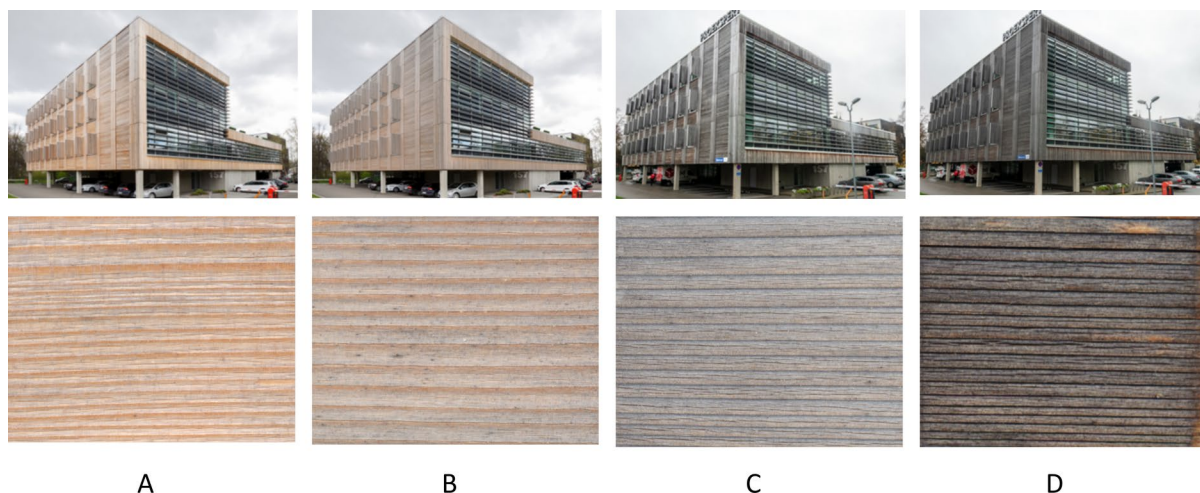
The respondents could choose one of the following five responses: Totally unacceptable, quite unacceptable, fairly acceptable, completely acceptable, and absolutely impossible to answer.

## 2.2 Acceptance rates for uncoated wooden cladding

The distribution of acceptance rates of the four panels A, B, C, and D, were calculated in percent for survey participants from Norway, Sweden, and Germany. The covariates (mean and standard deviation) of the acceptance rates were also calculated.

## 2.3 The statistical models and procedure

We constructed one latent variable for experience with a ‘wooden house/house with wooden cladding’, where we used one question concerning experience with living in a ‘wooden house/house with wooden cladding’ (Supporting Information (SI) Table S1a) and one question concerning experience with maintaining ‘wooden house/house with wooden cladding’ (SI Table S1b). Furthermore, we constructed a variable for the degree of risk aversion. To construct this variable, we used ten questions (SI Tables S2a–S2c) based on passive risk-taking (Keinan and Bereby-Meyer 2012). The five variables concerning the Big Five personality taxonomy are constructed from the 20 questions from the BFI-20 (Engvik and Claussen 2011), i.e. a short version of the Big Five personality inventory (SI Tables S3a–S3c). This version has also been used to find the connection between personality and consumption of local food specialities



**Fig. 1** Pictures of uncoated wooden cladding presented in the survey. Pictures of buildings were taken by Dr. Villu Kukk (TalTech, Tallinn, Estonia) the close-up pictures of the wood surface were taken by Dr. Anna Sandak and Dr. Jakub Sandak (InnoRenew, Izola, Slovenia)



(Gustavsen and Hegnes 2020a), organic food (Gustavsen and Hegnes 2020b), and drinking water (Gustavsen and Hegnes 2020c). The latent variables were constructed with the Graded Response Model (Samejima 1969). This statistical technique is a convenient way of constructing continuous latent variables from nominal graded survey questions. For the risk variable and the personality variables, 7-point Likert scales were used, while to construct the Experience variable, four categories were used.

### 2.3.1 The graded response model

The Graded Response Model is based on the logistic distribution function, and the probability for each individual  $j$  and question  $i$  to choose  $k$  from  $K$  choices is given by:

$$\begin{aligned}
 P(y_{ij} = k|\theta_j) &= P(y_{ij} \geq k|\theta_j) - P(y_{ij} \geq k + 1|\theta_j) \\
 &= \frac{\exp(\alpha_i(\theta_j - \beta_{ik}))}{1 + \exp(\alpha_i(\theta_j - \beta_{ik}))} - \frac{\exp(\alpha_i(\theta_j - \beta_{i,k+1}))}{1 + \exp(\alpha_i(\theta_j - \beta_{i,k+1}))}, \\
 k &= 1, 2, \dots, K
 \end{aligned}
 \tag{1}$$

$P(y_{ij} = k|\theta_j)$  is the probability for each individual  $j$  and question  $i$  to choose response  $k$ .  $\alpha_i$  is a discrimination parameter for question  $i$ .  $\beta_{ik}$  is a cutpoint parameter that identifies the boundaries between order outcomes.  $\theta_j$  is the latent variable of person  $j$ . When a 7-point Likert scale is used,  $K = 7$ , and when four categories are used,  $K = 4$ .

### 2.3.2 The ordered logistic regression model

Since the data were nominal with a natural ordering which represents grades of acceptance rates, the model chosen was the ordered logistic regression model. This probability model is described in Agresti (2002). The point of departure is the cumulative logistic distribution function  $H$ , such that the probability that an individual is in a category  $k$ , given a vector of covariates  $x$  is:

$$\Pr(y = k|x) = \begin{cases} H(\alpha_k - x'\beta), & k = 1 \\ H(\alpha_k - x'\beta) - H(\alpha_{k-1} - x'\beta), & 1 < k \leq K - 1 \\ 1 - H(\alpha_{k-1} - x'\beta), & k = K \end{cases}
 \tag{2}$$

where the  $\alpha_k$  are the cutoff points, and  $\beta$  is a vector of parameters. For each of the statements, this model can be estimated by maximum likelihood to find the optimal value of the parameters.

If  $y_{ik}$  is an indicator taking the value 1 if respondent  $i$  is in category  $k$ , and 0 otherwise. The likelihood function is then given by:

$$L = \prod_{i=1}^N \left[ \prod_{k=1}^K (H(\alpha_k - x'\beta) - H(\alpha_{k-1} - x'\beta))^{y_{ik}} \right]
 \tag{3}$$

The probability of finding the wooden cladding in the pictures fairly or completely acceptable is given as:

$$\Pr(y = (fa, ca)|x'\beta) = 1 - H(\alpha_2 - x'\beta)
 \tag{4}$$

In Eq. (4)  $(fa, ca)$  is fairly or completely acceptable.

The following procedure was used to evaluate the collected survey data: First, we constructed the latent variables for experience with wooden houses, risk aversion, and the Big Five personality taxonomy with the Graded Response Model, using Eq. (1). This was done based on data from the questions in SI Tables 1, 2, and 3. Secondly, all the continuous covariates were standardised to attain a mean of 0 and a standard deviation of 1. This was done to bring the covariates on the same scale. Thirdly, all the covariates in Table 2 were inserted into the ordered logistic regression models in Eq. (2) and estimated with the maximum likelihood technique with the likelihood function in Eq. (3). This was done using the Ologit procedure in the statistical software Stata (Statcorp 2017). The estimated parameters are shown in Table 3 for Norway, in Table 4 for Sweden, and in Table 5 for Germany.

Then, for each country and each panel, Eq. (4) was used to find the probabilities of acceptance for the mean and for subgroups. The probability of acceptance was found for the following subgroups: old individuals (90th quantile of age), young individuals (10th quantile of age), males, females, individuals with experience with wooden houses and individuals without experience, and individuals who prefer wooden cladding and individuals who prefer uncoated wooden cladding. For all the subgroups in focus, all the other covariates were kept at their mean values. Each model was bootstrapped with 500 iterations, to calculate standard errors. Finally, the differences in acceptance probability between subgroups were found and tested with t-tests.

### 2.3.3 Probabilities for subgroups

The acceptance probabilities of different degrees of discolouration of uncoated wooden claddings from each country is given in Tables 6, 7, and 8 including the predicted probabilities for the mean and for the subgroups. For the means, the probabilities were calculated with the mean value of all the covariates. For older individuals, the covariates, except for age, were kept at their mean, while age was kept at the 90th quantile of the age variable. For younger individuals, the covariates were kept at their mean, except for age, which was kept at the 10th quantile of the age variable. For males, the male variable was 1, while female was 0. The same procedure was used for the other categories in Tables 6, 7, and 8.

**Table 1** Acceptance rates (%) of panels A, B, C, and D, for participants from Norway, Sweden, and Germany

Country	Response alternative	Panel A	Panel B	Panel C	Panel D
Norway	Totally unacceptable	3.4	3.9	9.0	18.5
	Quite unacceptable	7.7	13.2	19.9	24.8
	Fairly acceptable	27.3	37.7	36.6	30.4
	Completely acceptable	57.4	40.8	30.9	22.3
	Absolutely impossible to answer	4.3	4.4	3.6	4.0
Sweden	Totally unacceptable	5.4	5.6	9.6	21.7
	Quite unacceptable	10.5	19.8	23.6	28.4
	Fairly acceptable	39.6	42.8	41.3	28.9
	Completely acceptable	37.2	25.6	19.3	14.8
	Absolutely impossible to answer	7.2	6.1	6.2	6.3
Germany	Totally unacceptable	5.0	4.9	7.5	18.1
	Quite unacceptable	11.5	15.0	24.3	27.5
	Fairly acceptable	39.6	46.5	40.6	30.3
	Completely acceptable	36.0	26.6	20.8	16.8
	Absolutely impossible to answer	8.0	7.0	6.8	7.3

### 3 Results and discussion

#### 3.1 Acceptance rate for uncoated wooden cladding

About 84% of the Norwegian participants thought that panel A was fairly or completely acceptable, while 79% accepted panel B and 68% accepted panel C (Table 1). Panel D was least accepted by Norwegian participants. Just 53% of the Norwegians thought that panel D was fairly or completely acceptable. Swedish and German participants responded similarly, but with a lower acceptance rate than Norwegian participants. Swedish participants responded with an acceptance rate for panels A to D of 77, 58, 61, and 44%, respectively, while German participants responded with acceptance rates for panels A to D of 76, 73, 61, and 47%, respectively.

To compare responses of the survey participants between the three countries, one should keep in mind how common wooden claddings are in the different countries. In Germany, the number of dwellings with wooden cladding is 22% (Holzbau Deutschland 2023), whereas in Sweden and Norway the majority of dwellings are made with wooden cladding. This is reflected in the survey responses (SI Table S1), where 88% of the respondents from Norway had a lot of experience or quite a lot of experience from living in a wooden house, and 64% had a lot of experience or quite a lot of experience from maintenance of a wooden cladding. In Sweden, these experience metrics amounted to 55% and 40%, respectively, while in Germany, it was only 17% and 15%, respectively. In the study by Viholainen et al. (2021) on citizen views regarding wood as a construction material, Norway and Sweden exhibited noticeably different perspectives on the acceptability of using wood compared to Germany. They suggested that the strong tradition of building with wood in Norway and Sweden is the most likely

explanation. The perspective from Viholainen et al. (2021) about Scandinavian peninsula countries vs. Germany could be used to explain the differences in acceptance of discolouration found in the current study.

#### 3.2 Covariates

The covariates are shown in Table 2. We found that in Norway, Sweden, and Germany, 54, 53, and 41%, respectively, preferred coated wooden cladding. In the same order, 18, 20, and 19% preferred uncoated wooden cladding. This meant that the omitted category (indifferent between the two categories), accounted for 28, 27, and 40%, respectively. Furthermore, males made up 48–50% of all the participants across the three countries, with mean age ranging from 47 to 49 years. Across the three countries, 32–48% lived in the suburbs, while 20–26% lived in rural areas. This meant that 32% of Norwegians, 44% of Swedes, and 36% of Germans lived in a city with more than 100,000 inhabitants. The socioeconomic characteristics reported that 51–68% of participants were married or cohabit, 26–32% had children under 18 years of age in their household, 85–95% of were born in Norway, Sweden, or Germany, and had at least one parent also born in the same country. Between 25 and 61% of participants had tertiary or college education, and the average household income per consumer unit in the three countries was 679,000 NOK (Norway), 364,000 SEK (Sweden), and 36,000 Euro (Germany). Income per consumer unit was measured as the total income in the household divided by the square root of the number of individuals in the household, as recommended by OECD (2008). By design, all the latent variables had a mean value close to 0 and a standard deviation close to 1.

**Table 2** Covariates of participants that responded to the survey regarding acceptance of greying and discolouration of wooden cladding

Covariates	Explanation	Norway	Sweden	Germany
Coated	= 1 if the individual prefers coated wooden cladding, 0 otherwise	0.54 (0.50)	0.53 (0.50)	0.41 (0.49)
Uncoated	= 1 if the individual prefers uncoated wooden cladding, 0 otherwise	0.18 (0.38)	0.20 (0.40)	0.19 (0.39)
Male	= 1 if male, 0 otherwise	0.48 (0.50)	0.50 (0.50)	0.49 (0.50)
Age	= Age of individual (years)	47.85 (16.18)	48.00 (16.84)	49.00 (0.16)
<i>Place of living</i>				
Suburb	= 1 if living in the suburb, 0 otherwise	0.48 (0.50)	0.32 (0.47)	0.38 (0.48)
Rural area	= 1 if living in a rural area, 0 otherwise	0.20 (0.40)	0.24 (0.43)	0.26 (0.44)
<i>Socioeconomics</i>				
Married	= 1 if married or cohabiting, 0 otherwise	0.68 (0.47)	0.53 (0.50)	0.51 (0.50)
Children in household	= 1 if one or more children are living in the household, 0 otherwise	0.31 (0.46)	0.32 (0.47)	0.26 (0.44)
Native	= 1 if the individual is born in the country and at least one of the parents is born in the country	0.95 (0.22)	0.84 (0.37)	0.90 (0.30)
University	= 1 if college education or higher, 0 otherwise	0.61 (0.49)	0.52 (0.50)	0.25 (0.43)
Income	= Household income per consumer unit (1,000 NOK, SEK, Euro)	679.09 (299.24)	363.73 (229.30)	36.35 (27.53)
<i>Latent variables</i>				
Experience	Degree of experience with living in and maintaining wooden houses	0.00 (0.84)	0.01 (0.89)	0.02 (0.86)
Risk averse	= Degree of risk aversion	0.00 (0.86)	0.00 (0.92)	0.00 (0.91)
<i>Personality (Big Five)</i>				
Extroversion	= Degree of extroversion	0.00 (0.90)	0.00 (0.90)	0.00 (0.94)
Agreeableness	= Degree of agreeableness	0.00 (0.86)	0.00 (0.91)	0.00 (0.89)
Conscientiousness	= Degree of conscientiousness	0.00 (0.83)	0.00 (0.82)	0.00 (0.88)
Emotional control	= Degree of emotional control	0.00 (0.91)	0.00 (0.91)	0.00 (0.90)
Openness to experience	= Degree of openness to experience	0.00 (0.89)	0.00 (0.89)	0.00 (0.91)
N	= Number of observations	1071	1030	1011

Mean values, standard deviation in parentheses

Since the use of uncoated wood cladding increases, it is interesting, and rather surprising, to see that the respondents in all three countries tend to prefer coated wood and that only around 20% of the respondents in each country prefer uncoated wooden cladding. Hence, the necessity for using the participants' sociodemographic and personality traits (Sects. 3.3 and 3.4 below) to explain the responses in acceptability between the three countries in more detail.

### 3.3 Model estimations

The results from model estimations are given in Tables 3, 4 and 5 for Norway, Sweden and Germany, respectively. The estimated parameters have no interpretation except for their sign (+ or -) and their significance. To find out about the effect of a parameter on the probability of accepting uncoated wooden cladding panels A–D (Fig. 1), some of the

**Table 3** Estimated model parameters for survey participants from Norway. Standard errors in parentheses

	Explanation	Panel A	Panel B	Panel C	Panel D
Coated	= 1 if the individual prefers coated wooden cladding, 0 otherwise	- 0.67*** (0.17)	- 0.91*** (0.15)	- 1.03*** (0.15)	- 1.10*** (0.15)
Uncoated	= 1 if the individual prefers uncoated wooden cladding, 0 otherwise	0.34 (0.23)	0.44** (0.21)	0.73*** (0.20)	0.26 (0.18)
Male	= 1 if male, 0 otherwise	- 0.17 (0.15)	- 0.24* (0.14)	- 0.19 (0.13)	- 0.30** (0.13)
Age	= Age of individual	- 0.45*** (0.08)	- 0.22*** (0.08)	- 0.04 (0.07)	- 0.08 (0.07)
<i>Place of living</i>					
Suburb	= 1 if living in the suburb, 0 otherwise	- 0.03 (0.16)	- 0.19 (0.15)	- 0.20 (0.15)	- 0.08 (0.14)
Rural area	= 1 if living in a rural area, 0 otherwise	- 0.20 (0.20)	- 0.22 (0.19)	- 0.15 (0.18)	0.11 (0.18)
<i>Socioeconomics</i>					
Married	= 1 if married or cohabiting, 0 otherwise	0.21 (0.16)	0.20 (0.15)	0.09 (0.14)	0.10 (0.14)
Children in household	= 1 if one or more children are living in the household, 0 otherwise	- 0.14 (0.17)	0.11 (0.16)	0.17 (0.15)	0.17 (0.14)
Native	= 1 if the individual is born in the country and at least one of the parents is born in the country	0.37 (0.31)	- 0.10 (0.30)	0.27 (0.28)	- 0.06 (0.27)
University	= 1 if college education or higher, 0 otherwise	0.59*** (0.15)	0.60*** (0.14)	0.37*** (0.14)	0.26* (0.13)
Income	= Household income per consumer unit (1,000 NOK, SEK, Euro)	0.02 (0.08)	- 0.01 (0.07)	0.04 (0.07)	- 0.05 (0.06)
<i>Latent variables</i>					
Experience	= Degree of experience with living in and maintaining wooden houses	- 0.01 (0.08)	0.07 (0.08)	0.06 (0.07)	0.10 (0.07)
Risk averse	= Degree of risk aversion	- 0.06 (0.08)	- 0.07 (0.07)	- 0.09 (0.07)	- 0.07 (0.07)
<i>Personality (Big Five)</i>					
Extroversion	= Degree of extroversion	- 0.23*** (0.08)	- 0.21*** (0.07)	- 0.20*** (0.07)	- 0.13* (0.07)
Agreeableness	= Degree of agreeableness	0.08 (0.07)	0.07 (0.07)	0.03 (0.07)	- 0.03 (0.06)
Conscientiousness	= Degree of conscientiousness	0.00 (0.08)	- 0.10 (0.07)	- 0.14** (0.07)	- 0.09 (0.07)
Emotional control	= Degree of emotional control	0.04 (0.08)	0.18** (0.07)	0.14* (0.07)	0.17*** (0.07)
Openness to experience	= Degree of openness to experience	0.26*** (0.08)	0.25*** (0.07)	0.20*** (0.07)	0.11* (0.06)
$\alpha_1$	= First cut-off parameter	- 3.26 *** (0.41)	- 3.76*** (0.40)	- 2.57*** (0.36)	- 2.04*** (0.34)
$\alpha_2$	= Second cut-off parameter	- 1.93*** (0.37)	- 1.93*** (0.37)	- 1.03*** (0.34)	- 0.74** (0.33)
$\alpha_3$	= Third cut-off parameter	- 0.12 (0.38)	0.12 (0.36)	0.82** (0.34)	0.81** (0.33)

Note: Standard error in parentheses. \*\*\* = significant at 1% level, \*\* = significant at 5% level, \* = significant at 10% level

estimated parameters can be substituted into the probability functions in Eq. (4) while holding the other parameters fixed at their means. Hence, probabilities for different groups can be found and differences between subgroups can be tested. This is done in Tables 6, 7 and 8.

### 3.3.1 Norway

The results from the four estimated models for Norway are given in Table 3 and the significant parameters are summarised in this paragraph. The biggest effect on the



**Table 4** Estimated model parameters for survey participants from Sweden. Standard errors in parentheses

	Explanation	Panel A	Panel B	Panel C	Panel D
Coated	= 1 if the individual prefers coated wooden cladding, 0 otherwise	- 0.76*** (0.17)	- 0.68*** (0.16)	- 0.59*** (0.16)	- 0.56*** (0.15)
Uncoated	= 1 if the individual prefers uncoated wooden cladding, 0 otherwise	- 0.13 (0.20)	0.05 (0.19)	0.31* (0.19)	0.44** (0.19)
Male	= 1 if male, 0 otherwise	- 0.57*** (0.14)	- 0.57*** (0.13)	- 0.53*** (0.13)	- 0.39*** (0.13)
Age	= Age of individual	- 0.04 (0.08)	-0.04 (0.07)	- 0.14* (0.08)	- 0.15** (0.07)
<i>Place of living</i>					
Suburb	= 1 if living in the suburb, 0 otherwise	- 0.16 (0.15)	- 0.20 (0.15)	0.07 (0.15)	- 0.07 (0.14)
Rural area	= 1 if living in rural area, 0 otherwise	0.20 (0.18)	0.14 (0.17)	0.18 (0.15)	-0.15 (0.17)
<i>Socioeconomics</i>					
Married	= 1 if married or cohabit, 0 otherwise	0.01 (0.14)	0.08 (0.14)	- 0.03 (0.14)	0.07 (0.13)
Children in household	= 1 if one or more children are living in the household, 0 otherwise	0.13 (0.16)	0.09 (0.15)	-0.07 (0.15)	-0.14 (0.15)
Native	= 1 if individual is born in country and at least one of the parents are born in the country	0.00 (0.18)	- 0.01 (0.18)	- 0.41** (0.17)	- 0.33* (0.17)
University	= 1 if college education or higher, 0 otherwise	0.32** (0.14)	0.36*** (0.13)	0.20 (0.13)	0.16 (0.13)
Income	= Household income per consumer unit (1,000 NOK, SEK, Euro)	0.15** (0.07)	0.12* (0.07)	0.09 (0.07)	-0.03 (0.07)
<i>Latent variables</i>					
Experience	= Degree of experience with living in and maintaining wooden houses	- 0.08 (0.07)	- 0.03 (0.07)	0.06 (0.07)	0.02 (0.07)
Risk averse	= Degree of risk aversion	0.17** (0.07)	0.21*** (0.07)	0.12* (0.07)	0.04 (0.07)
<i>Personality (Big Five)</i>					
Extroversion	= Degree of extroversion	- 0.19** (0.08)	- 0.15** (0.07)	- 0.19*** (0.07)	- 0.11 (0.07)
Agreeableness	= Degree of agreeableness	0.19** (0.08)	0.07 (0.08)	-0.03 (0.08)	-0.09 (0.07)
Conscientiousness	= Degree of conscientiousness	- 0.03 (0.08)	- 0.17** (0.08)	- 0.26*** (0.08)	- 0.23*** (0.07)
Emotional control	= Degree of emotional control	0.08 (0.08)	0.06 (0.08)	0.11 (0.08)	0.11 (0.07)
Openness to experience	= Degree of openness to experience	0.12 (0.08)	0.08 (0.08)	0.18** (0.08)	0.15** (0.08)
$\alpha_1$	= First cut-off parameter	- 3.45 *** (0.30)	- 3.29*** (0.29)	- 3.00*** (0.27)	- 1.96*** (0.25)
$\alpha_2$	= Second cut-off parameter	- 2.22*** (0.27)	- 1.44*** (0.26)	- 1.38*** (0.25)	- 0.51** (0.24)
$\alpha_3$	= Third cut-off parameter	- 0.07 (0.26)	0.64*** (0.25)	0.71*** (0.25)	1.12*** (0.25)

Note: Standard error in parentheses. \*\*\* = significant at 1% level, \*\* = significant at 5% level, \* = significant at 10% level

acceptance probabilities of panels A–D (Fig. 1) was whether individuals preferred coated or uncoated wooden cladding, or if they were indifferent to coated and uncoated panels. Individuals who preferred coated wooden cladding were least likely to accept any of the panels. On the

other hand, individuals who preferred uncoated wooden cladding were most likely to accept panels B and C. Furthermore, males showed lower acceptance probability than females for panels B and D, while individuals with a higher age showed lower acceptance for panels A and

**Table 5** Estimated model parameters for survey participants from Germany. Standard errors in parentheses

	Explanation	Panel A	Panel B	Panel C	Panel D
Coated	= 1 if the individual prefers coated wooden cladding, 0 otherwise	- 0.11 (0.15)	- 0.37** (0.15)	- 0.75*** (0.15)	- 0.76*** (0.14)
Uncoated	= 1 if the individual prefers uncoated wooden cladding, 0 otherwise	0.56*** (0.19)	0.54*** (0.19)	0.56*** (0.19)	0.48*** (0.18)
Male	= 1 if male, 0 otherwise	- 0.07 (0.14)	- 0.14 (0.14)	0.04 (0.13)	- 0.00 (0.13)
Age	= Age of individual	- 0.10 (0.08)	- 0.11 (0.08)	0.02 (0.08)	0.12 (0.08)
<i>Place of living</i>					
Suburb	= 1 if living in the suburb, 0 otherwise	0.39** (0.15)	0.17 (0.15)	0.17 (0.15)	-0.13 (0.15)
Rural area	= 1 if living in rural area, 0 otherwise	0.32* (0.17)	0.18 (0.17)	0.21 (0.17)	- 0.01 (0.16)
<i>Socioeconomics</i>					
Married	= 1 if married or cohabit, 0 otherwise	0.09 (0.15)	0.13 (0.15)	-0.02 (0.14)	-0.09 (0.14)
Children in household	= 1 if one or more children are living in the household, 0 otherwise	- 0.05 (0.17)	- 0.13 (0.15)	- 0.28* (0.17)	0.14 (0.17)
Native	= 1 if individual is born in country and at least one of the parents are born in the country	0.65*** (0.23)	0.40* (0.24)	0.08 (0.23)	- 0.15 (0.23)
University	= 1 if college education or higher, 0 otherwise	0.22 (0.16)	0.16 (0.16)	0.09 (0.15)	0.03 (0.15)
Income	= Household income per consumer unit (1,000 NOK, SEK, Euro)	0.10 (0.07)	0.12* (0.07)	0.09 (0.07)	0.03 (0.07)
<i>Latent variables</i>					
Experience	= Degree of experience with living in and maintaining wooden houses	- 0.27*** (0.07)	- 0.04 (0.07)	0.06 (0.07)	0.18*** (0.07)
Risk averse	= Degree of risk aversion	0.12* (0.08)	0.05 (0.07)	0.05 (0.07)	0.04 (0.07)
<i>Personality (Big Five)</i>					
Extroversion	= Degree of extroversion	- 0.12 (0.09)	- 0.07 (0.08)	- 0.05 (0.08)	0.04 (0.08)
Agreeableness	= Degree of agreeableness	0.18* (0.09)	0.08 (0.09)	0.01 (0.09)	- 0.17* (0.09)
Conscientiousness	= Degree of conscientiousness	0.09 (0.10)	0.07 (0.10)	- 0.03 (0.10)	0.07 (0.10)
Emotional control	= Degree of emotional control	0.09 (0.07)	0.04 (0.07)	0.02 (0.07)	0.00 (0.07)
Openness to experience	= Degree of openness to experience	0.30*** (0.10)	0.28*** (0.10)	0.26*** (0.09)	0.12 (0.09)
$\alpha_1$	= First cut-off parameter	- 2.18 *** (0.30)	- 2.63*** (0.31)	- 2.69*** (0.29)	- 1.91*** (0.28)
$\alpha_2$	= Second cut-off parameter	- 0.69*** (0.27)	- 0.94*** (0.28)	- 0.76*** (0.27)	- 0.41 (0.27)
$\alpha_3$	= Third cut-off parameter	1.42*** (0.28)	1.39*** (0.28)	1.26*** (0.27)	1.19*** (0.27)

Note: Standard error in parentheses. \*\*\* = significant at 1% level, \*\* = significant at 5% level, \* = significant at 10% level

B than younger individuals. College-educated individuals accepted the panels more than individuals without college education. There were also differences in acceptance probabilities related to personality. Extroverted individuals showed less acceptance of panels A–D than introverted

individuals, while individuals with good emotional control, i.e. those who were less nervous, showed higher acceptance of panels B–D. Also, persons who showed a high degree of openness to experience, individuals with artistic interests and new ideas, showed acceptance for all

**Table 6** Acceptance probabilities of different degrees of discolouration of uncoated wooden claddings for survey participants from Norway (%)

	Panel A	Panel B	Panel C	Panel D
Mean	90.81 (0.91)	84.52 (1.16)	72.70 (1.46)	56.14 (1.76)
Old individuals	84.24 (1.91)	80.06 (2.19)	71.66 (2.50)	53.39 (2.99)
Young individuals	94.63 (0.86)	87.94 (1.49)	73.66 (2.39)	58.70 (2.87)
Male	90.03 (1.27)	82.79 (1.68)	70.73 (2.03)	52.34 (2.44)
Female	91.50 (0.95)	86.00 (1.28)	74.47 (1.93)	59.64 (2.26)
High experience	90.70 (1.25)	85.44 (1.52)	74.06 (2.11)	58.75 (2.72)
Low experience	90.98 (1.35)	83.07 (2.20)	70.62 (2.95)	52.23 (3.26)
Prefer coated cladding	87.24 (1.38)	76.91 (1.79)	59.39 (2.23)	42.52 (2.31)
Prefer uncoated cladding	94.97 (1.01)	92.78 (1.24)	89.47 (1.51)	74.12 (2.85)
<i>Differences between groups</i>				
Old-Young	- 10.39*** (2.13)	- 7.88*** (2.87)	- 2.01 (3.92)	- 5.31 (4.70)
Males-Females	- 1.46 (1.28)	- 3.21* (1.84)	- 3.75 (2.68)	- 7.30** (3.15)
Experienced-Not experienced	- 0.29 (1.88)	2.37 (2.87)	3.43 (4.09)	6.53 (4.84)
Coated-Uncoated	- 7.73*** (1.49)	- 15.87*** (2.02)	- 30.08*** (2.67)	- 31.60*** (3.63)

Note: Standard error in parentheses. \*\*\* = significant at 1% level, \*\* = significant at 5% level, \* = significant at 10% level

**Table 7** Acceptance probabilities of different degrees of discolouration of uncoated wooden claddings for survey participants from Sweden (%)

	Panel A	Panel B	Panel C	Panel D
Mean	84.80 (1.24)	73.55 (1.55)	65.99 (1.76)	46.40 (1.87)
Old individuals	85.43 (1.61)	72.69 (2.36)	62.04 (2.72)	41.93 (2.85)
Young individuals	84.08 (2.04)	74.52 (2.63)	70.24 (3.05)	51.57 (3.50)
Male	80.75 (1.66)	67.57 (2.12)	59.79 (2.39)	41.60 (2.47)
Female	88.11 (1.39)	78.72 (1.85)	71.62 (2.16)	51.21 (2.53)
High experience	83.02 (2.38)	72.50 (2.86)	68.03 (3.28)	47.29 (3.66)
Low experience	86.29 (1.64)	74.48 (2.41)	64.08 (2.92)	45.59 (3.29)
Prefer coated cladding	80.01 (1.72)	66.67 (2.10)	57.97 (2.48)	37.74 (2.25)
Prefer uncoated cladding	88.26 (1.57)	80.50 (2.29)	77.28 (2.56)	62.43 (3.27)
<i>Differences between groups</i>				
Old-Young	1.35 (2.69)	- 1.82 (3.91)	- 8.19* (4.62)	- 9.63* (5.16)
Males-Females	- 7.36*** (1.85)	- 11.15*** (4.28)	- 11.83** (5.12)	-9.60 (5.87)
Experienced-Not experienced	- 3.28 (3.16)	- 1.98 (2.87)	3.96 (4.09)	1.71 (4.84)
Coated-Uncoated	- 8.25*** (2.01)	- 13.83*** (2.97)	- 19.31*** (3.38)	- 24.68*** (3.79)

Note: Standard error in parentheses. \*\*\* = significant at 1% level, \*\* = significant at 5% level, \* = significant at 10% level

panels A-D. Further, respondents low on conscientiousness accepted panel C.

### 3.3.2 Sweden

Table 4 shows the estimated model parameters for Sweden and the significant parameters are summarised in this paragraph. Swedish individuals who preferred coated wooden cladding showed lower acceptance rates for panels A-D than those who were indifferent. Also, those who preferred uncoated showed a higher acceptance probability for panels C and D than the indifferent group. Males showed a lower acceptance probability than females for all the panels, and

young respondents showed higher acceptance for panels C and D. Individuals born in Sweden with at least one parent born in Sweden, showed a lower acceptance probability of panels C and D than respondents with immigration background. University-educated individuals had more acceptance of panels A and B than individuals without university education, while no difference in acceptance of panels C and D was registered for this group. Individuals with high income accepted panel A and B. Risk-averse individuals accepted panels A, B, and C, while the risk parameter for panel D was not significantly different from zero at 10% significance level. Differences in personality between respondents meant that individuals low on extroversion, i.e.

**Table 8** Acceptance probabilities of different degrees of discolouration of uncoated wooden claddings for survey participants from Germany (%)

	Panel A	Panel B	Panel C	Panel D
Mean	83.48 (1.29)	79.69 (1.49)	66.85 (1.78)	50.02 (1.82)
Old individuals	81.91 (1.88)	77.73 (2.06)	67.32 (2.57)	53.31 (2.68)
Young individuals	85.44 (1.96)	82.16 (2.44)	66.21 (3.38)	45.53 (3.68)
Male	82.98 (1.61)	78.55 (1.87)	67.32 (2.33)	49.99 (2.47)
Female	83.96 (1.56)	80.74 (1.78)	66.40 (2.38)	50.04 (2.53)
High experience	76.91 (2.38)	78.70 (2.58)	68.73 (2.94)	56.91 (3.23)
Low experience	86.45 (1.44)	80.23 (1.77)	65.78 (2.33)	46.16 (2.49)
Prefer coated cladding	80.99 (1.87)	74.04 (2.13)	53.85 (2.58)	36.82 (2.47)
Prefer uncoated cladding	89.31 (1.53)	87.62 (1.98)	81.20 (2.39)	67.00 (3.34)
<i>Differences between groups</i>				
Old-Young	− 3.54 (2.87)	− 4.43 (3.40)	1.11 (4.74)	7.77 (5.20)
Males-Females	− 0.98 (1.85)	− 2.19 (2.13)	0.92 (3.09)	0.04 (3.44)
Experienced-Not experienced	− 9.53*** (2.75)	− 1.53 (3.09)	2.95 (3.85)	10.75** (4.43)
Coated-Uncoated	− 8.33*** (2.11)	− 13.57*** (2.54)	− 27.35*** (3.32)	− 30.18*** (4.12)

Note: Standard deviations in parentheses

introverts, showed higher acceptance for panels A, B, and C. Further, individuals high on altruism showed acceptance for panel A. Finally, individuals with low conscientiousness showed acceptance for panels B, C, and D, while individuals with a high degree of openness to experience showed high acceptance of panels C and D.

### 3.3.3 Germany

The estimated parameters for the models relevant to the German participants in the survey are shown in Table 5 and the significant parameters are summarised in this paragraph. Compared to the indifferent group, individuals who preferred coated wooden cladding showed low acceptance rates for panels B, C, and D. Furthermore, individuals who preferred uncoated wooden cladding showed high acceptance probability for all the panels. Individuals who lived in the suburbs or in rural areas showed higher acceptance of panel A than individuals who lived in a city. For panels A and B, individuals native to Germany showed higher acceptance than respondents with immigration background, but no difference in acceptance was registered regarding panel C or D. Individuals with experience in maintaining and/or living in a wooden house had lower acceptance probability for panel A, but higher acceptance probability for panel D than those without experience. Individuals with high risk aversion accepted panel A. For Germans, the personality trait openness to experience had a positive effect on the acceptance probability for panels A, B, and C. Respondents high on altruism accepted panel A and respondents low on altruism accepted panel D.

The clear statement from all three countries in this survey is that individuals that prefer coated wooden cladding do not

accept the uncoated wood panels with different degree of discolouration. Respondents who prefer uncoated cladding were most likely to accept panels B and C in Norway, panel C and D in Sweden and all panels in Germany. Why all panels were accepted in Germany while the lightest panel was not accepted in Norway and Sweden is puzzling. It might be historically rooted in the common use of wood as a building material in Norway and Sweden. The light initial colour of an untreated wooden cladding is rare since discolouration is initiated at the time of installation (Gobakken et al. 2008, 2010; R  ther and Time 2015) and for the Scandinavian participants the light colour might be perceived as unfamiliar.

Place of living was only significant for panel A in Germany and was accepted by individuals who lived in the suburbs or in rural areas. This is probably because Germany has more big cities than Norway and Sweden and because wooden cladding is for frequently used outside the cities in Germany.

More detailed between country comparison of model parameters about perception of the different wood panels are given below in 3.3.4 (socioeconomics) and 3.3.4 (latent variables) while between country comparison subgroups dealing with age, gender, experience and preference for coated vs. uncoated is given in 3.4.

### 3.3.4 Between country comparison of model parameters—socioeconomics

The socioeconomic parameter married or cohabit was not found to be significant for any of the wood panels in any of the three countries. One or more children in the household was not significant for any of the panels in Norway or Sweden but was found to be significant for panel C in Germany

for households without children. This single result is difficult to interpret in a between-country context, and it seemingly occurs as a bit random that panel C is preferred (10% significance level).

For panels A and B, individuals native to Germany showed higher acceptance than respondents with non-German backgrounds, while respondents with non-Swedish backgrounds accepted panels C and D. It is hard to draw conclusions from these results, but as cultural background influences perception, it is feasible that it also effects perception of discolouration of untreated wood cladding. For Norway this parameter was not significant for any of the wood panels. One reason could be that Norway is less ethnically diverse than Sweden and Germany.

Respondents with university education in Norway (all panels) and Sweden (panel A and B) showed acceptance for discolouration while this parameter was not significant in Germany. We know from previous literature that, in general, university-educated consumers play a significant role in influencing the demand for wood-framed houses (Loučanová and Olšiaková 2020b). University students, particularly prioritise eco-labelling when assessing certified wood products, with a focus on wood flooring (Roos and Hugosson 2008). Moreover, consumers with secondary education also exhibit preferences for eco-labelled wood products (Roos and Nyrud 2008). Additionally, higher levels of education correlate with a greater willingness to pay to support modern wood structures with environmentally conscious features (Luo et al. 2017). Environmental aspects could potentially explain the lack of significance in Germany. Viholainen et al. (2021) found that respondents from Germany were more sceptical about the environmental impacts of harvesting timber for wood materials than respondents from Norway and Sweden. Another explanation could be the diverse perspectives between the two countries with a long history of building with wood, and Germany (Viholainen et al. 2021).

Respondents with high income preferred panel A and B in Sweden and panel B in Germany, while in Norway no significant effect of income was found. Why respondents with high income preferred the lighter-coloured wood panels is hard to evaluate. It can be hypothesised that lighter-coloured wood can be perceived as more refined and elegant, aligning with the desire of high-income individuals to reflect their status and taste.

### 3.3.5 Between country comparison of model parameters—latent variables

Degree of experience was not a significant parameter in Norway or Sweden, but significant effects were found (for panel A and D) in Germany. Viholainen et al. (2021) found noticeably different views on the acceptability of wood in Norway and Sweden vs. Germany, and this could explain

the difference in acceptance for discolouration between the countries. In Norway and Sweden, most participants will be accustomed to the discolouration of wood exposed outdoors. Therefore, the variation between respondents high and low in experience is lower, leading to a more uniform interpretation of the discolouration of the cladding in the populations. Interestingly, individuals in Germany low on experience showed the highest acceptance probability for panel A, whereas those high on experience demonstrated the highest acceptance rate for panel D. Consumers tend to prefer light or moderate colour intensity (Nyrud et al. 2008; Lowell et al. 2015) and this supports that those low in experience prefer the lighter colour. Further, another explanation could be that those with extensive experience understand that wood material exposed outdoors naturally changes colour and that the effect is primarily aesthetic.

Using the questions from Keinan and Bereby-Meyer (2012) about daily-risk perception we found that, in Sweden, risk-averse (i.e., reluctant to take risks) individuals accepted panel A–C. Risk aversity was not significant in Norway or Germany, except for panel A among German participants. The results from Norway and Germany could imply that the perception of discolouration of wooden cladding is linked to aesthetic. The unexpected acceptance among risk-averse individuals in Sweden could potentially be linked to lower maintenance requirements, i.e., coating challenges and recoating are not relevant for uncoated wood and therefore accepting of discolouration would avoid additional expenses.

Introverted individuals in Norway (panel A–D) and Sweden (panel A–C) preferred the wood panels more than extroverted respondents. The reason could be that extroverts are characterised by high amounts of emotional expressiveness: it is possible that they find grey cladding less exciting (old or neglected) than a coated wooden cladding (fresh and lively). The parameter Extroversion was not significant for the German participants. When Norway and Sweden group together vs. Germany the results from Viholainen et al. (2021) could be applied, i.e. more experience with wooden cladding in Norway and Sweden gives a different cultural background for perceptions than in Germany.

In Sweden and Germany, those with a high degree of agreeableness accepted panel A more than those with a low degree of agreeableness. In Norway agreeableness was not significant. Those high in agreeableness can be described as sensitive to the needs of others and are helpful and cooperative. One hypothesis is that individuals high in agreeableness might prefer options that appear well-kept and inviting, reflecting their concern for the well-being and comfort of others. In Germany, those with a low degree of agreeableness accepted panel D more than those with a high degree of agreeableness. Those low on agreeableness tend to prioritise their own needs and desires over those of others and are less



willing to assist others. Hence, they may not care about the severe discolouration.

In Sweden, individuals high in conscientiousness showed a low acceptance for panels B–D. In Norway, the same was found, but only for panel C. Characteristics of those high in conscientiousness include competence, organisation, dutifulness, achievement striving, self-discipline and deliberativeness, while those low in conscientiousness can be characterised as disorganised, careless, procrastinative, undisciplined and impulsive. Hence, uncoated wooden panels could potentially be perceived as neglected or untidy and therefore, not appealing to those high in conscientiousness. Also, here the two Scandinavian peninsula countries group together (Viholainen et al. 2021). Since wooden cladding is less frequent in Germany the population in general might be less engaged in discolouration of wooden cladding, and therefore the discolouration is less provoking for those with high conscientiousness.

In Norway, participants with a high degree of Openness to Experience accepted all panels, while in Sweden, panels C and D were accepted, and in Germany, panels A–C were accepted. This could be explained by the fact that uncoated wooden cladding is still rather unconventional. Openness to Experience is previously reported to be positively associated with appreciation of aesthetic quality (McManus and Furnham 2006) and aesthetic emotions (Fayn et al. 2015). People who register high on openness to experience are characterised as curious, imaginative, creative, open to trying new things, and unconventional, while those who register low on openness to experience are characterised as predictable, not very imaginative, dislike change, prefer routine, and traditional. Since several of the panels were accepted in all countries it is hard to interpret between country variations. In a study of consumer personality traits vs. their preferences for the characteristics of wood furniture products, no correlation between openness and consumer preference was found (Yu et al. 2023).

Panels B–D were accepted in Norway by individuals with strong emotional control: this parameter was not significant in Sweden or Germany. Characteristics of individuals with strong emotional control include minimal worry and high confidence which could explain the acceptance for the discoloured wood. As the emotional control parameter was only significant in Norway, one explanation could be minimal worry and high confidence combined with Norway being the country with the most experience with wood (SI Table S1a,b).

### 3.4 Probabilities for subgroups

Tables 6, 7, and 8 show the predicted probabilities for the mean and for the subgroups.

#### 3.4.1 Norway

Table 6 shows the results for Norway. Mean acceptance for each panel and the significant responses from group comparisons are summarised in this paragraph. More than 90% of Norwegians thought that panel A was fairly or completely acceptable. Roughly 85% thought that panel B was acceptable, while 73% and 56% thought that panels C and D were acceptable. The highest acceptance probability for all the panels was the category that preferred uncoated wooden cladding. For panels A and B, the second highest acceptance was from young individuals, while for panel D, the third highest acceptance was from females.

#### 3.4.2 Sweden

Table 7 shows the results for Sweden. Mean acceptance for each panel and the significant responses from group comparisons are summarised in this paragraph. The probability of fairly or completely accepting panel A was 85% for Swedish participants. For panels B, C, and D, the acceptance rates were 74, 66, and 46%, respectively. As in Norway, the highest acceptance probability for all the panels was the category that preferred uncoated wooden cladding. For panel A, B and C the second highest acceptance was from females, but for panel D, no significant difference between males and females was registered. Furthermore, young people showed higher acceptance rates for panels C and D, but not for A and B.

#### 3.4.3 Germany

Table 8 shows the results for Germany. Mean acceptance for each panel and the significant responses from group comparisons are summarised in this paragraph. For German participants 84% found panel A fairly or completely acceptable, while roughly 80% accepted panel B, 67% panel C and 50% panel D. Again, those who preferred uncoated wooden cladding showed the highest acceptance probability of all panels overall. The only other group difference arose between those who had a lot of experience with maintaining and/or living in wooden houses and those who had not. For panel A, the acceptance probability was highest among those with little experience, while for panel D, the acceptance rate was highest among those with high experience. There were no differences registered for panels B and C.

#### 3.4.4 Between country comparison subgroups

As expected, in all three countries, those who prefer uncoated cladding had a higher acceptance for the discolouration of panels A–D than those who preferred coated wooden cladding. The mean acceptance of all the

panels was higher in Norway than in Sweden and Germany. Swedes and Germans showed similar acceptance for panels A and C, while Germans showed a slightly higher acceptance for panel B and panel D than Swedes.

When used uncoated, all wood materials will turn grey when exposed outdoors (Hirche 2014; Zabel and Morell 2020). In this survey, we selected a building with homogeneous discolouration to rule out the effect of heterogeneous appearance as an effect of design details because previous studies showed that consumers prefer homogeneous visual wood material properties (Marchal and Mothe 1994; Broman 2000; Høibø and Nyrud 2010; Brischke and Kaudewitz 2015; Gellerich et al. 2017). For many years, the wood gradually gets darker until it reaches a rather stable grey or brown colour. The duration of this process depends on the material, design, and climate (Rüther and Time 2015). In all three countries, the acceptance was highest for the newly exposed wood with a lighter colour, while the acceptance probabilities declined with increasing exposure (i.e. once the wood turned darker). One interpretation of the results from the survey could be that the dark wood is less appealing. This is in line with previous studies where consumers preferred light or moderate colour intensity (Nyrud et al. 2008; Lowell et al. 2015).

In Norway and Sweden, young people showed a higher acceptance towards discolouration of the wooden cladding. However, in Norway, younger participants showed higher acceptance for the early stages of discolouration (panels A–B, lighter shade of grey), while in Sweden, younger participants showed higher acceptance for the later stages of discolouration (panels C–D, darker shade of grey). Regarding age-related findings in the review by Harju (2022), it was suggested that younger consumers tend to value environmental certification (Thompson et al. 2010) and prioritise environmentally friendly materials. Younger consumers were also identified as the optimal target demographic for wood-based urban housing (Høibø et al. 2015) and wood-framed houses (Loučanová and Olšiaková 2020).

In Norway and Sweden, females showed more acceptance for discolouration of wooden cladding than males. In Norway, females showed higher acceptance for panels B and D, while in Sweden, females showed higher acceptance for panels A–C, i.e., contradictory to the findings for younger participants, in general. From previous studies (Harju 2022), female consumers showed a preference for eco-labelled wood products (Roos and Nyrud 2008). Additionally, it was observed that females who valued durability, solidity, and environmental friendliness, and who possessed extensive knowledge about wood along with experiences of residing in wooden houses, exhibited stronger preferences for wood as a material (Høibø et al. 2015).

### 3.5 Practitioner implications and future research needs

Our findings are in line with Harju (2022), who revealed in a comprehensive review study that socio-demographic characteristics (age, gender, income, education), and psychographic traits (experience, knowledge, values) play key roles in consumers' behaviours. For instance, educated and young consumers tend to favour wood. Sandak et al. (2015) revealed a shift in tolerance for surface imperfections after participants learned about the effort required for frequent repairs. The current study does not include the time factor or the cost. Both factors are likely to affect consumer perception and should be considered in future studies.

Since consumers prefer homogeneous visual properties (Marchal and Mothe 1994; Broman 2000; Nyrud et al. 2008; Høibø and Nyrud 2010; Brischke and Kaudewitz 2015; Gellerich et al. 2017) one of the main challenges with uncoated wooden cladding is likely the period of change rather than the final weathered result. By performing a 'pre-weathering' (e.g. using iron sulphate) the consumer will not experience years with colour change, but instead receive a stable grey product from the beginning. Since uncoated cladding is not yet very frequently used, another challenge might be that some consumers will associate uncoated wooden cladding with sheds or other 'low status' buildings. Furthermore, as pointed out by Sandak et al. (2015), information and knowledge on service life performance is important for the acceptance of weathered wooden materials.

Brischke et al. (2019) found that the anticipated duration of use seemed to vary based on the respondents' country of origin. Service life is determined by limit states and exposure conditions that should be defined independently of user perceptions. While consumer perceptions vary between regions and countries, prediction models can still be applied universally. Nonetheless, service life expectations need to be determined carefully at the national or even regional level, taking into account the personal traits of target customer groups for effective service life planning.

Like all cross-sectional studies, this one has its own set of limitations. When a survey company conducts an online survey, they select a sample of individuals from a panel that is intended to represent the population based on certain criteria, such as age, gender, and location. However, a panel is not independent as it is recruited via the internet, leading to possible selection bias (Bethlehem 2010). Consequently, we do not know if our samples from Norway, Sweden, and Germany responded as if they were selected independently from the three populations. Additionally, when individuals respond to a survey about choices, one might question whether their responses truly reflect their real-life behaviour. Jerolmack and Khan (2014) suggested that people's statements often do not accurately predict their actions. Further

research about perception of uncoated wooden cladding should use other data samples and other methods to replicate our results. Other personality taxonomies may be used, additional experiments may be designed, and the longitudinal data from experiments may be analysed with alternative methods for choice analysis.

The main contribution of this study is to link consumer tolerance of discolouration of wooden cladding with personality traits. The information gathered in the current study could be used for marketing purposes. However, from a consumer point of view, this knowledge is also important when planning a building to avoid premature maintenance (e.g. replacement) procedures, where the user/consumer experiences product performance differing from what was anticipated. When planning for an uncoated wooden facade, the customer should be informed about how the product will change colour and the effect of design details that could lead to a heterogeneous appearance. The current study also provides valuable insights for contractors to improve user satisfaction and for policymakers to better advocate a transition to a lower-carbon economy (Vehola et al. 2022). Further, in LCC calculations, it can be beneficial to additionally include more practical scenarios where limit states are instead influenced by user preferences, as identified in this study.

## 4 Conclusion

This study fills a knowledge gap regarding the aesthetic and psychological acceptance of wooden cladding. Despite the variations in the prevalence of wooden cladding, the preference for uncoated wooden cladding is surprisingly consistent across Norway, Sweden, and Germany, of around 20%. This indicated a shared perception or cultural influence concerning the attractiveness of uncoated wood. Among those who preferred uncoated wood, Norwegians preferred the intermediate-coloured panels (A and B), Swedes preferred the darker panels (C and D) while all panels were accepted by Germans.

When considering socio-demographic factors and personality traits, we found that in Norway and Sweden (i.e. countries with long tradition with the use of wood), those accepting the discolouration of uncoated wooden cladding included introverted individuals, those with high conscientiousness, young people, females, and those with tertiary education. Additionally, in Norway and Germany, respondents with openness to experience also accepted the discolouration, while the personality trait of strong emotional control was significant only in Norway.

These findings highlight that consumers' perceptions of the aesthetic qualities of wood, including its natural discolouration over time, are influenced not only by functional aspects but also by psychological and cultural dimensions.

By connecting consumer preferences to practical applications for uncoated wooden materials, this study contributes to advancing wood utilisation in construction, offering valuable insights to manufacturers, builders, and policymakers regarding potential market acceptance.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s00107-025-02235-x>.

**Acknowledgements** Thanks to Dr. Villu Kukk (TalTech, Tallinn, Estonia) for pictures of the building with wooden cladding and to Dr. Anna Sandak & Dr. Jakub Sandak (InnoRenew, Izola, Slovenia) for the closeup pictures of the wood surfaces.

**Author contributions** GWG, PBvN, JN, CB, GA planned and conducted the surveys. GWG did the statistical analyses. GWG, PBvN, JN, CB, GA wrote the main manuscript text.

**Funding** Open access funding provided by Norwegian Institute of Bioeconomy Research. This work (project WoodLCC) is supported under the umbrella of ERA-NET Cofund ForestValue by the Ministry of Education, Science and Sport (MIZS) - Slovenia; The Ministry of the Environment (YM) - Finland; Research Council of Norway (RCN) - Norway; The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS), Swedish Energy Agency (SWEA), Swedish Governmental Agency for Innovation Systems (Vinnova) - Sweden; Estonian Ministry of the Environment; Estonian Research Council; Federal Ministry of Food and Agriculture (BMEL) and Agency for Renewable Resources (FNR) - Germany. Forest Value has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773324.

**Data availability** The full dataset is available from the authors on request.

## Declarations

**Conflict of interest** The authors declare no competing interests.

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