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Relationships between environmental attitudes, appraisals of wooden environments, and wood use behavior in Japan

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Abstract

Globally, wood is being increasingly used as a strategy for decarbonization. The present study investigated the relationship between environmental attitudes and behaviors related to the use of wood. Participants from the public in Japan rated online photos of wooden environments and reported on their environmental concerns and awareness concerning the use of wood. Study 1 ($N=768$) revealed that environmental concerns, as measured by the New Ecological Paradigm scale, significantly influenced preference for wooden living spaces. In Study 2 ($N=737$), the structural equation model revealed the psychological processes underlying prior experiences, attitude, intention to purchase, and willingness to pay for wooden interiors. The results suggest the importance of strengthening connections with nature and providing knowledge about forest certifications as potential intervention strategies to promote sustainable wood use.

Keywords Wooden interior, Environmental appraisal, Wood use, Attitudes, Sustainability, Structural equations

Introduction

Studies have shown that wood interiors affect people both physiologically and psychologically [1, 2]. A recent survey conducted in seven European countries revealed that following fire safety, a healthy environment was often cited as an important factor in the appeal of living in multi-story wooden buildings [3]. Furthermore, it has been pointed out that beliefs regarding the environmental impact of wood construction vary depending on individual attributes [4] and that values influence the intention to use wood products [5]. These findings highlight the need for a more detailed understanding of the perspective of consumers who use wood.

This study focused on the use of wood as an option for pro-environmental behavior and sought to clarify the psychological mechanisms influencing its selection to further encourage people to incorporate wood interiors. This research is significant within the context of global efforts to achieve net-zero emissions by 2050 [6]. Sustainably sourced wood products can aid decarbonization by storing absorbed carbon, offering individuals a way to contribute to climate efforts through informed material choices. Whether wood products have been sourced sustainably can be verified through forest certification systems, where third-party organizations verify and certify that timber production and logging practices meet standards for legality and sustainability. Japan's forest certification system is the SGEC (Sustainable Green Ecosystem Council), which has mutual certification with the PEFCTM (Pan European Forest Certification Schemes). SGEC has a larger certified area than the FSC[®] (Forest Stewardship Council[®]), which is a global certification system; however, a recent survey showed that FSC[®] is more recognized than SGEC/PEFCTM in Japan [7].

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Japan has advanced in modernization, yet it maintains a relatively high degree of cultural homogeneity, with many traditional elements still present in its way of life. Japan's climate is warm and rainy, and its abundance of mountains and forests has traditionally provided ample timber. Consequently, many wooden products are used in daily life, and the country has had a tradition of using wood as a building material, particularly prior to modern times.

Additionally, due to the prevalence of hot and humid regions during the summer, traditional houses have historically required openness. Therefore, rather than wall-enclosed construction methods, pillar-supported methods were preferred, and then, in pre-modern times, wooden architecture was favored over stone or brick structures in this regard. Furthermore, as the country experiences frequent natural disasters such as earthquakes, typhoons, tsunamis, volcanic eruptions, and major urban fires, wooden architecture was well-suited for reconstruction and recovery. Even today, the proportion of wooden structures in new single-family homes remains extremely high at approximately 90% [8]. Furthermore, Japan differs from European countries in its tendency to use wood in the visible parts of buildings to highlight its beauty. Watanabe [9] has noted that Japan originally lacked a word equivalent to the Western concept of "nature", and even today, the clear distinction between nature and artificial objects remains ambiguous. In the traditional view of nature, humans were likely considered part of nature.

Now, forests account for two-thirds of the national land area, and about 40% of them are planted forests. Moreover, about half of the planted forests are over 50 years old and have reached the period of use [8]. In addition to decarbonization, many functions of forests such as water source recharging and disaster prevention may go unrealized without the use of wood. Therefore, promoting the use of wood has become a crucial issue in Japan, particularly in recent years. Unfortunately, the decarbonization potential of using wood, especially from a consumer perspective, is often overlooked. A recent international comparative study on climate anxiety, well-being, and pro-environmental action [10] did not mention wood use in its list of sustainable consumption behaviors [11]. Similarly, a review on CO₂ emission mitigation in the housing sector [12] highlighted renewable electricity as a key factor but did not consider the impact of wooden construction. In fact, research suggests that wood as a building material faces biases and concerns about its climate and biodiversity effects, even in Nordic countries [4, 13].

In this study, participants were presented with online photos of wooden environments and asked to report their environmental concerns and attitudes toward wood

use, along with some psychological indicators. The aim was to fill the gap in knowledge about the mechanisms and measures for promoting the use of wood to ensure decarbonization. To this end, this study comprehensively clarified the attitudes and behaviors related to the use of wood by drawing on theories of attitudes, values, and behaviors that have been accumulated to date. Although this study only targeted Japanese residents, the results may also help other regions by clarifying the behaviors related to the use of wood based on the widely known New Environmental/Ecological Paradigm (NEP) scale [14, 15].

Value orientations, beliefs, and attitudes

Attitudes and behaviors are not always aligned, especially for pro-environmental behaviors such as recycling [16]. In the context of climate change, there has been an increase in recent years in the number of studies investigating the relationship between values, beliefs, attitudes, and climate anxiety [10, 11, 17–20]. Here, we first briefly review a classical theory, Ajzen's Theory of Reasoned Action (TRA) [21]. TRA is frequently used to predict both behavioral intentions and behaviors based on attitudes and subjective norms. According to the TRA, behavior is related to attitudes through intentions. Attitudes are determined by an individual's beliefs regarding the consequences of behavior and their evaluation of these consequences. In addition, values are core beliefs that are more stable than attitudes and affect these evaluations.

Therefore, when we seek to understand and promote wood use behavior, values and attitudes matter. Moreover, to summarize very briefly the numerous studies that have been conducted on value orientations, beliefs, and attitudes in the environmental context, environmental concern can be categorized into three values: social-altruistic, biospheric (also referred to as ecocentrism), and egoistic or self-interest (also called anthropocentrism) [22–24]. The NEP scale is designed to measure a new ecological worldview rather than just one aspect of attitude while encompassing both ecocentrism and anthropocentrism.

NEP and related scales

The NEP scale is widely regarded as the most used measure of environmental attitudes in the literature [25–27]. The scale represents a fundamental shift in how people view the relationship between nature and people. A comparative survey of the United States and Japan [28] revealed that the statements represented by NEP items were endorsed by respondents in both countries, but the NEP score was higher in Japan than in the United States. Compared to Americans, fewer Japanese people thought

that “the human is dominant”, indicating that the new environmental paradigm is not entirely new in Japan. As pointed out in the review study [29], environmental attitudes are influenced by gender, age, and a combination of 18 categories of personal and social factors; the effects of these are extremely complex.

Meanwhile, there has been a recent increase in the number of scales and studies that focus on the connection between humans and nature from a slightly different perspective to the NEP. For example, the Nature Relatedness scale (NR) [30] and its brief version (NR-6) [31] were developed to address the Connected to Nature Scale [32], which lacks physical aspects. The authors of these studies proposed that nature relatedness represents an “individual level of connectedness with the natural world” and confirmed that it correlated with the NEP and other environmental scales, environmental behavior, and frequency of time spent in nature. Since then, the NR/NR-6 has been used in many studies as a comprehensive measure of the connection between people and nature [33–36].

Research questions

In this study, we used the NEP to measure attitudes regarding the relationship between humans and the environment in Studies 1 and 2. In Study 2, we also employed the NR to measure relatively stable and “trait-like” [30] connectedness with nature. Study 1 primarily examined factors influencing preferences for wooden environments, while Study 2, based on TRA, comprehensively aimed to explore the relationship between these attitudes, intentions, and behaviors related to the use of wood, including factors of NR and preference for wooden environments. In summary, the following research questions were assessed:

1. Do environmental attitudes measured by the NEP scale influence preference for wooden environments? (Study 1)
2. If so, how are environmental attitudes, and the intention and behavior to wood use related? (Study 2)

Study 1

Method

We used an online survey of the public in Japan. This and the following studies were conducted with the approval of the research ethics committee of the authors’ affiliated institute (Permit No. 22M-7 on December 15, 2022). The survey form included details on its purpose, and respondents’ completion of the questionnaire was considered implied consent to participate. The purpose of this study was explained in the following sentence: “This survey aims to clarify awareness regarding living spaces.”

Participants

Participants completed an online questionnaire survey delivered through a research company in January 2023. Seven hundred and eighty adults residing in Japan (390 males and 390 females) participated in this study. The samples were recruited to be equal in gender, age (20, 30, 40, 50, 60), and place of residence (metropolitan areas, other areas). We considered the metropolitan areas as Tokyo (Japan’s most densely populated region) and its surrounding three prefectures (Saitama, Chiba, and Kanagawa Prefecture), as well as Osaka (Japan’s second most densely populated region) and its surrounding three prefectures (Kyoto, Hyogo, and Nara Prefecture).

We determined the sample size considering the results of a priori power analysis using G*Power 3.1. To examine the effects of gender and place of residence, we calculated the sample size assuming that these effects would be small ($d=0.2$, α value of 0.05, power of 0.8). The result was an N of 620; thus, the sample size was set at 700. Excluding the respondents who selected the same response to all stimuli, the following analysis included 768 responses (386 males and 382 females). The average age of the participants was 44.58 years (SD (standard deviation) = 14.01), with a range from 20 to 69 years old.

Materials

We used 20 office photos, with 16 taken by the first author or the related institutions, and 4 sourced from a stock photo company. All photos are shown in Fig. 1. The former 16 photos mainly included real wood surfaces, while the latter 4 photos (photos 1, 5, 11, and 16) may have printed wood patterns. The wood ratio, calculated as the proportion of wood/wood pattern pixels to total pixels, ranged from 0 to 77% across the 20 images. Specifically, areas that the first author determined to be recognized as wood by humans were manually painted over and counted as wood pattern.

Measures

Participants rated a series of stimuli for the 20 photos. Specifically, they indicated their preference (*favorable–unfavorable*), 6 visual properties (*simple–complex*, *familiar–novel*, *conservative–advanced*, *dark–bright*, *artificial–natural*, *unopen–open*), 2 aspects of affective appraisals (*unpleasant–pleasant*, *boring–exciting*), 2 restorative properties (*Being here doesn’t refresh me.–Being here refreshes me.*, *Being here doesn’t make me feel the fascination of the place.–Being here makes me feel the fascination of the place.*) of the environments, and the amount of subjective wood (*I feel like wood is being used.–I don’t feel like wood is being used.*) using 5-point bipolar scales, where 3 represents neutral. We adopted

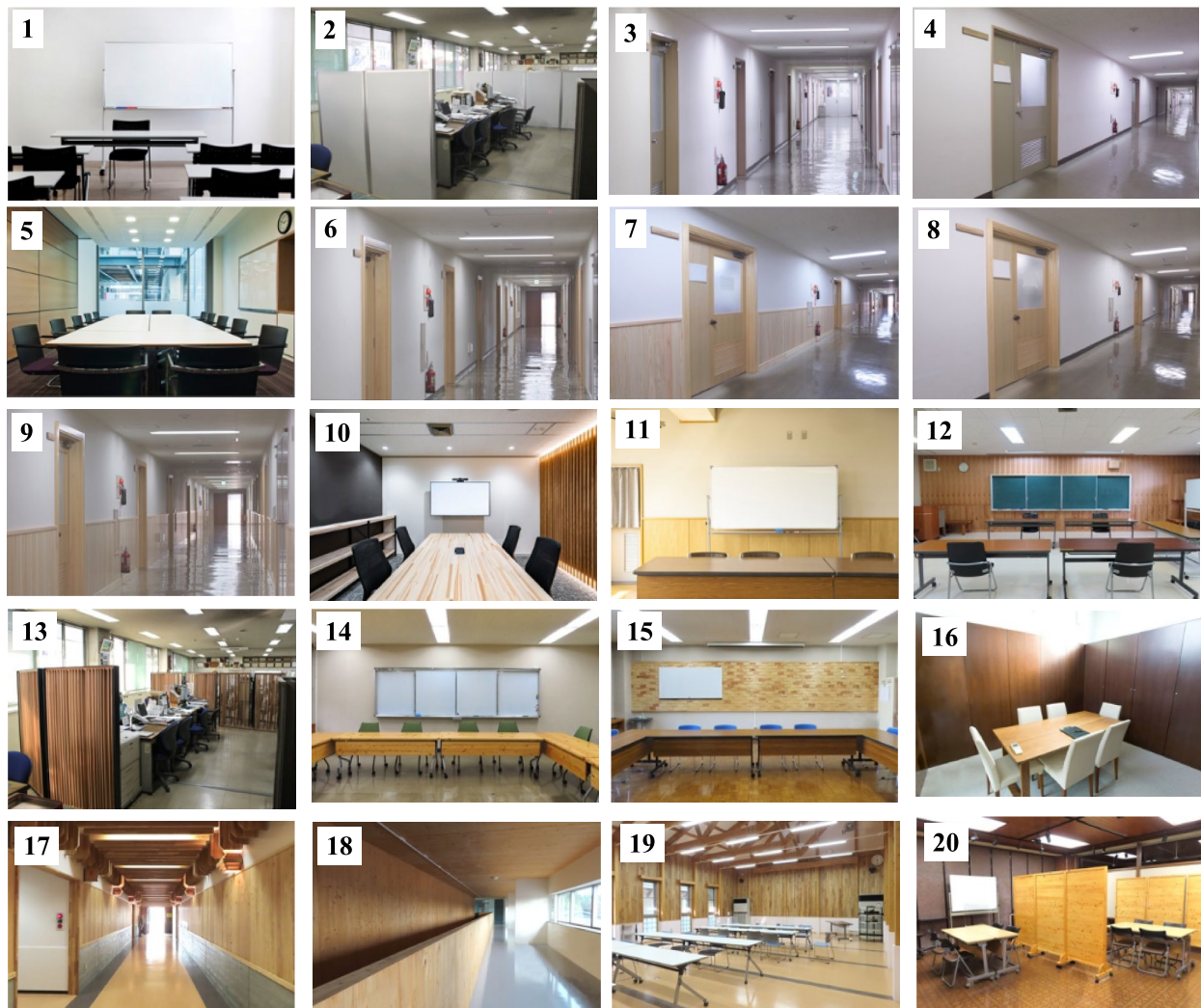


Fig. 1 Twenty office photos. Photos 1–4 show non-wooden interiors, and photos 5–20 show wooden interiors. Photos 2–4 include very small portion of wood in nameplates or picture frames in the office

the visual properties and two representative affective appraisals based on previous research [37, 38], and two items regarding the restorative factors of being-away and fascination [39, 40].

Fifteen items of the NEP scale [15] translated by the authors with reference to [41] were used. In addition, we constructed 13 items regarding participants' awareness of the environment and wood use. In constructing the items, we referenced [42], who investigated university students' awareness and knowledge about wood use in Japan. All items are shown in Table 1. Participants rated the above-mentioned items on 5-point scales ranging from 5 = strongly agree to 1 = strongly disagree. The survey included other items, but only the items relevant to this study are provided in this report.

Procedure

After providing their demographic information, such as age, gender, place of residence, marital status, whether they had children, and annual household income, participants rated the 20 stimuli and then completed the other items related to environmental concerns. The stimuli were presented in random order.

Data analysis

The analyses were performed in R 4.4.0 [43] using the following packages: psych [44] and GPARotation [45] for calculating the effect size and conducting an exploratory factor analysis.

Table 1 Means and results of the exploratory factor analysis of the awareness of the environment and wood use

	Item	M	SD	Factor loading			Communality
				1	2	3	
E12	I know the meaning of this mark. ^a	2.08	1.14	0.91	0.22	0.05	0.87
E13	When purchasing products, I pay attention to the display of certification marks like this	2.20	1.10	0.80	0.29	0.09	0.73
E11	I have seen this mark before	2.43	1.32	0.68	0.15	0.12	0.50
E6	I have experience in activities related to forest protection (e.g., volunteering for tree planting and forest development)	2.23	1.18	0.55	0.41	0.02	0.47
E8	Your family or close friends actively use wood products	2.72	0.95	0.27	0.81	0.25	0.80
E9	Your acquaintances actively use wood products	2.69	0.96	0.33	0.81	0.17	0.79
E7	I actively use wood products in my daily life	2.91	0.98	0.28	0.66	0.36	0.64
E10	I have experience making things using wood outside of school classes	2.94	1.22	0.15	0.46	0.23	0.29
E3	I am interested in protecting forests	3.34	0.97	0.20	0.24	0.77	0.69
E1	I am interested in environmental issues	3.23	1.00	0.18	0.16	0.76	0.63
E5	I think it is good to use thinned wood to protect the environment [Thinned wood] Wood that is made from trees that have been felled to reduce overcrowding to maintain a healthy forest	3.68	0.92	-0.12	0.10	0.62	0.41
E2	I know about SDGs	3.48	0.98	0.07	0.11	0.54	0.31
E4	I think it is good to use wood to protect the environment	3.43	0.88	0.05	0.21	0.51	0.31
Sum of square loadings				2.60	2.43	2.41	7.44
Cumulative proportion				0.20	0.39	0.57	

N = 768. M = mean. SD = standard deviation. Maximum likelihood method with a varimax rotation was used. Factor loadings above 0.30 are in bold.

^aThe forest certification mark (FSC® logo) was displayed with this item.

Results

Appraisals of wooden interiors

The results of the appraisals of all 20 stimuli are shown in Table 2. The mean of the preference was 2.81 (SD = 0.29, Min. = 2.26, Max. = 3.39). Overall, the evaluation was not high. We already reported that the correlation between wood ratio and preference was moderate (r = 0.58 [95% CI (confidence interval) 0.19, 0.82], p < 0.01) [46]. The correlation between preference and the amount of subjective wood was relatively high (r = 0.76 [95% CI 0.48, 0.90], p < 0.001). Furthermore, there was a significant correlation between the amount of subjective wood and wood ratio (r = 0.78 [95% CI 0.52, 0.91], p < 0.001).

NEP scale

To enable comparisons with previous studies, we first calculated the mean of the NEP and considered the score differences by age, place of residence, and gender.

The mean NEP score was 49.23 (SD = 5.51, Min. = 15, Max. = 75), which was slightly lower compared to Sasaki [41] in Japan (52.6) and Choi and Fielding [47] in Australia (51.9, SE (standard error) = 0.19). Cronbach’s α was relatively low (α = 0.64 [95% CI 0.60, 0.68]). The correlation between the NEP scores and age was 0.24 [95% CI 0.17, 0.31], which was smaller than in previous studies. We used a t-test to compare differences in the NEP scores by gender and place of residence: females scored

significantly higher (M = 49.74) than males (M = 48.72) (t (763.63) = - 2.58, p = 0.01, Cohen’s d = 0.19 [95% CI 0.04, 0.32]), and metropolitan residents scored significantly higher (M = 49.75) than the others (M = 48.70) (t (766) = 2.66, p = 0.008, Cohen’s d = 0.19 [95% CI 0.05, 0.33]).

We conducted an exploratory factor analysis, assuming a two-factor structure using all 15 items. Table 3 shows the results. As expected, mainly odd-numbered items had high factor loadings on Factor 1, which we labeled *Ecocentric*. Even-numbered items had high factor loadings on Factor 2, which we labeled *Anti-Anthropocentric*. Although items 4 and 9 had negative loadings on the wrong factor and the communalities of items 6 and 8 were low, we retained them because we did not aim to create or refine the scale. The minimum average partial (MAP) criterion suggested two factors, and in alignment with a recent study conducted in Japan [41], we estimated two factor scores—*Ecocentric* and *Anti-Anthropocentric*.

Awareness of the environment and wood use

For the 13 items on awareness of the environment and wood use, we conducted an exploratory factor analysis assuming a three-factor structure based on the MAP criterion and the results of parallel analysis. Means, SD, factor loadings, and communalities of the factor analysis are shown in Table 3. As seen in Table 1, the forest

Table 2 Means (SD) of appraisals of all stimuli

Photo	Preference	Affective appraisals			Visual properties			Restorative properties				Amount of subjective wood	Wood ratio
		Pleasant	Arousal	Complexity	Novelty	Progressiveness	Brightness	Naturalness	Openness	Fascination			
										Being away	Fascination		
1	2.67 (0.82)	2.73 (0.81)	2.44 (0.86)	1.97 (0.95)	2.08 (0.96)	2.30 (1.00)	3.01 (0.99)	2.29 (0.97)	2.58 (1.00)	2.32 (0.93)	2.30 (0.94)	1.84 (0.95)	0.00
2	2.26 (0.90)	2.30 (0.90)	2.17 (0.92)	2.54 (1.14)	2.19 (0.96)	2.11 (0.92)	2.23 (0.97)	2.07 (0.93)	2.04 (0.95)	1.99 (0.91)	2.01 (0.90)	1.81 (0.96)	0.02
3	2.43 (0.86)	2.45 (0.85)	2.27 (0.90)	2.10 (0.96)	2.14 (0.91)	2.16 (0.89)	2.32 (0.96)	2.21 (0.94)	2.28 (0.99)	2.16 (0.94)	2.16 (0.93)	2.13 (1.00)	0.02
4	2.50 (0.86)	2.50 (0.84)	2.31 (0.87)	2.07 (0.89)	2.15 (0.90)	2.19 (0.90)	2.26 (0.94)	2.26 (0.95)	2.38 (0.98)	2.16 (0.90)	2.19 (0.92)	2.15 (1.03)	0.01
5	3.13 (0.80)	3.15 (0.76)	3.00 (0.82)	2.69 (0.93)	2.92 (0.97)	3.20 (0.97)	3.49 (0.89)	2.67 (0.96)	3.29 (0.98)	2.79 (0.88)	2.89 (0.92)	2.74 (0.95)	0.26
6	2.64 (0.84)	2.64 (0.82)	2.40 (0.84)	2.24 (0.93)	2.35 (0.89)	2.39 (0.88)	2.55 (0.94)	2.55 (0.93)	2.49 (0.95)	2.33 (0.92)	2.35 (0.91)	2.76 (0.99)	0.16
7	2.98 (0.84)	2.98 (0.82)	2.68 (0.76)	2.36 (0.87)	2.66 (0.86)	2.68 (0.85)	3.02 (0.95)	3.01 (0.97)	2.88 (0.94)	2.69 (0.93)	2.68 (0.93)	3.48 (1.00)	0.35
8	2.79 (0.82)	2.82 (0.79)	2.58 (0.80)	2.31 (0.89)	2.52 (0.90)	2.55 (0.86)	2.82 (0.95)	2.83 (0.92)	2.75 (0.94)	2.50 (0.89)	2.52 (0.91)	3.19 (0.98)	0.20
9	2.82 (0.82)	2.82 (0.81)	2.55 (0.80)	2.36 (0.89)	2.48 (0.87)	2.55 (0.89)	2.82 (0.99)	2.77 (0.94)	2.68 (0.94)	2.54 (0.90)	2.54 (0.90)	3.18 (1.04)	0.33
10	3.39 (0.88)	3.40 (0.86)	3.16 (0.79)	2.71 (0.98)	3.27 (0.95)	3.46 (0.94)	3.55 (0.89)	3.19 (0.97)	3.16 (1.01)	3.16 (0.90)	3.21 (0.91)	3.72 (0.94)	0.31
11	2.86 (0.81)	2.90 (0.81)	2.54 (0.83)	2.13 (0.92)	2.31 (0.93)	2.38 (0.92)	3.14 (0.94)	2.90 (0.93)	2.94 (0.97)	2.55 (0.90)	2.55 (0.89)	3.26 (0.98)	0.33
12	2.62 (0.86)	2.67 (0.80)	2.45 (0.84)	2.23 (0.97)	2.39 (0.94)	2.33 (0.91)	2.60 (0.94)	2.61 (0.90)	2.68 (1.01)	2.35 (0.89)	2.35 (0.91)	3.15 (1.02)	0.31
13	2.54 (0.88)	2.57 (0.88)	2.51 (0.87)	2.93 (1.04)	2.93 (0.99)	2.65 (0.90)	2.58 (0.95)	2.61 (0.91)	2.46 (0.97)	2.33 (0.92)	2.37 (0.94)	3.09 (1.03)	0.31
14	2.68 (0.81)	2.75 (0.79)	2.50 (0.82)	2.29 (0.90)	2.48 (0.90)	2.50 (0.92)	2.85 (0.94)	2.71 (0.91)	2.71 (1.00)	2.44 (0.89)	2.48 (0.91)	3.17 (1.01)	0.13
15	2.90 (0.84)	2.93 (0.78)	2.75 (0.79)	2.58 (0.96)	2.86 (0.95)	2.80 (0.90)	3.17 (0.88)	2.94 (0.89)	2.94 (0.96)	2.67 (0.89)	2.69 (0.88)	3.45 (0.97)	0.56
16	2.84 (0.91)	2.86 (0.87)	2.58 (0.83)	2.24 (0.92)	2.66 (0.91)	2.65 (0.92)	2.80 (0.97)	2.69 (0.94)	2.28 (1.00)	2.56 (0.97)	2.60 (0.95)	3.26 (1.01)	0.77
17	3.15 (0.85)	3.18 (0.85)	2.98 (0.76)	2.98 (1.01)	3.30 (0.93)	3.08 (0.87)	3.27 (0.88)	3.28 (0.99)	3.15 (0.96)	3.04 (0.90)	3.04 (0.91)	3.91 (0.99)	0.53

Table 2 (continued)

Photo	Preference	Affective appraisals		Visual properties			Restorative properties			Amount of subjective wood	Wood ratio		
		Pleasant	Arousal	Complexity	Novelty	Progressiveness	Brightness	Naturalness	Openness			Being away	Fascination
18	3.10 (0.89)	3.08 (0.84)	2.87 (0.83)	2.60 (1.07)	3.32 (0.94)	3.11 (0.90)	3.21 (0.99)	3.23 (0.98)	3.19 (1.01)	3.03 (0.97)	2.96 (0.92)	3.85 (1.02)	0.70
19	3.17 (0.83)	3.23 (0.80)	2.96 (0.74)	2.60 (0.98)	3.02 (0.93)	2.96 (0.89)	3.57 (0.88)	3.34 (0.97)	3.60 (0.92)	3.00 (0.89)	3.00 (0.91)	3.86 (1.00)	0.39
20	2.68 (0.90)	2.72 (0.84)	2.58 (0.84)	2.57 (1.04)	2.94 (0.91)	2.71 (0.87)	2.86 (0.93)	2.79 (0.96)	2.66 (1.01)	2.50 (0.93)	2.44 (0.92)	3.41 (0.99)	0.37

preference to amount of subjective wood, the items were rated on a 5-point scale ranging from 1 (e.g., *unpleasant*) to 5 (e.g., *pleasant*). Wood ratio was calculated as the ratio of the number of pixels in the wood part on the screen to the number of pixels on the entire screen (ranging from 0 to 1). The wood ratio was calculated as the proportion of wood/wood pattern pixels to total pixels.

Table 3 Means and results of the exploratory factor analysis of the NEP scale

	Item	M	SD	Factor loading		Communality	
				1	2		
NEP15	If things continue on their present course, we will soon experience a major ecological catastrophe	3.68	0.88	0.78	0.06	0.62	
NEP5	Humans are severely abusing the environment	3.80	0.85	0.75	0.12	0.58	
NEP13	The balance of nature is very delicate and easily upset	3.72	0.87	0.69	0.05	0.49	
NEP11	The earth is like a spaceship with very limited room and spaces	3.58	0.88	0.68	-0.01	0.46	
NEP7	Plants and animals have as much right as humans to exist	3.74	0.86	0.65	0.05	0.43	
NEP1	We are approaching the limit of the number of people the earth can support	3.55	0.89	0.60	0.04	0.36	
NEP3	When humans interfere with nature it often produces disastrous consequences	3.65	0.88	0.55	0.03	0.31	
NEP4	Human ingenuity will ensure that we do NOT make the earth unlivable	2.42	0.83	- 0.53	0.18	0.31	
NEP12	Humans were meant to rule over the rest of nature	3.26	1.03	0.14	0.73	0.56	
NEP2	Humans have the right to modify the natural environment to suit their needs	3.13	0.98	0.11	0.69	0.49	
NEP9	Despite our special abilities humans are still subject to the laws of nature	3.00	0.94	0.03	- 0.65	0.42	
NEP14	Humans will eventually learn enough about how nature works to be able to control it	3.19	0.99	0.10	0.63	0.40	
NEP10	The so-called "ecological crisis" facing humankind has been greatly exaggerated	3.05	0.86	0.07	0.61	0.37	
NEP6	The earth has plenty of natural resources if we just learn how to develop them	2.82	0.88	-0.16	0.38	0.17	
NEP8	The balance of nature is strong enough to cope with the impacts of modern industrial nations	2.62	0.87	-0.33	0.34	0.23	
Sum of square loadings					3.67	2.51	6.17
Cumulative proportion					0.24	0.41	

N = 768. Maximum likelihood method with a varimax rotation was used. Even-numbered items are reversed items. Factor loadings above 0.30 are in bold. On the NEP scale, agreement with odd-numbered items and disagreement with even-numbered items indicate a pro-environmental orientation. Therefore, the NEP scale score was calculated by reversing odd-numbered items and then summing the scores of all 15 items. Cronbach's $\alpha = 0.64$ [95% CI 0.60, 0.68]

certification mark is not well known among the public. Regarding Factor 2, the items related to family, acquaintances, and one's daily use of wood showed higher loadings. Finally, items related to interest in environmental issues, especially protecting forests, had higher factor loadings on Factor 3; people showed a relatively high level of interest in this factor. Moreover, there was a certain level of awareness and correct understanding of thinned wood. To summarize, these three factors were *awareness of forest certification*, *daily use of wood products*, and *interest in environmental issues*, respectively.

The influence of environmental concern, awareness of the environment, and wood use on preference for wooden living spaces

To examine the influence of environmental concern and other demographic variables on the preference for wooden spaces, we conducted a hierarchical multiple regression analysis, a method of performing multiple regression analysis in several steps, incrementally adding explanatory variables to the model at each step. By adding explanatory variables step by step, we can determine the incremental increase in the coefficient of determination resulting from adding variables.

We conducted the hierarchical multiple regression analysis using the amount of subjective wood as an explanatory variable and the average preferences for the 16 stimuli of wooden living space that had a wood ratio exceeding 1% as a dependent variable (Step 1). In the next step, we included age (reference = 20 s), the factor scores of NEP, and the awareness of the environment and wood use (Step 2). We included the variable as a decade rather than age because prior studies [48, 49] conducted in Japan suggested generational differences in environmental awareness. We then performed a multiple regression analysis including additional demographic variables, such as gender, place of residence, marital status, and whether they had children. None of these variables were significant, and the R^2 value remained nearly unchanged. Therefore, we selected the model that included only age as the demographic variable. Given that 170 respondents answered that they did not know their annual household income, we did not include income as a predictor.

Table 4 shows the results of the hierarchical multiple regression model. In Step 1, examining the R^2 change from Step 1 to Step 2, the result was significant ($\Delta R^2 = 0.072$, $F(9, 757) = 10.14$, $p < 0.001$). This suggests that environmental concern and awareness of the

Table 4 Results of the hierarchical multiple regression predicting preference for wooden environments

Variable	β	SE β	95% CI for β		R^2	ΔR^2
			LL	UL		
Step 1					0.329	
Amount of subjective wood	0.573***	0.030	0.515	0.631		
Step 2					0.401	0.072***
Amount of subjective wood	0.600***	0.030	0.542	0.659		
Age 30 s(reference = 20 s)	0.077	0.090	-0.099	0.253		
Age 40 s	0.155 [†]	0.091	-0.024	0.333		
Age 50 s	-0.009	0.093	-0.191	0.174		
Age 60 s	-0.034	0.093	-0.217	0.148		
Ecocentric (NEP)	-0.127***	0.038	-0.202	-0.052		
Anti-Anthropocentric (NEP)	-0.196***	0.035	-0.264	-0.128		
Awareness of forest certification	0.052	0.033	-0.013	0.118		
Daily use of wood products	0.079*	0.032	0.015	0.142		
Interest in environmental issues	0.091*	0.04	0.014	0.169		

*** $p < 0.001$, * $p < 0.05$, [†] $p < 0.10$.

environment and wood use may affect the preference for wooden living spaces. When other explanatory variables were held constant, environmental concern was low, and the level of interest in environmental issues and daily use of wooden products was high; furthermore, the preference for the wooden environment was high, as indicated by the standard partial regression coefficient (β).

Discussion

In Study 1, the results showed that environmental concerns or other attitudes influenced the preference for wooden living spaces. More specifically, when environmental concern was low, and the level of interest in environmental issues and daily use of wooden products was high, the preference for wooden environments was higher. However, Study 1 had some limitations. Specifically, wood ratio and the amount of subjective wood were used as a key indicator of the photos; however, other factors, such as brightness, color temperature, and furniture layout in the photographs, which were not controlled for in this study, may influence preference. Moreover, although a relatively strong correlation was observed between wood ratio and the amount of subjective wood, it is also possible that specific visual properties of the photos—such as naturalness, novelty, or openness—may have increased the amount of subjective wood. Considering that the amount of subjective wood was strongly related to preference than wood ratio in this study, research that uses photos should note that the amount of subjective wood may vary depending on the shooting angle, even when the actual wood usage is identical. Therefore, both the physical wood ratio and the

participants' subjective wood ratio should be carefully considered.

Furthermore, the economic factors were missing both in the predictors and the outcomes in Study 1. Adding the factors of intention to purchase and willingness to pay for the wooden environments, we conducted Study 2. By including nature experience and nature-relatedness as individual factors, Study 2 aimed to clarify more comprehensively the relationship between environmental attitudes, awareness of wood use, and behavioral intention based on TRA.

Study 2

Method

We conducted an online questionnaire survey delivered through a research company in the same manner as in Study 1 in November 2023.

Participants

Seven hundred and forty adults residing in Japan (370 males and 370 females) participated in this study. The sample attribute distribution and sample size calculation methods are similar to those of Study 1. The analysis included 737 responses (367 males and 370 females), and the average age of the participants was 44.73 years ($SD = 13.82$ years), ranging from 20 to 69 years old.

Materials

Six photos (photos 1, 5, 10, 11, 12, 16 in Fig. 1) were selected from the 20 photos used in Study 1. Regarding the visual properties obtained in Study 1, moderate to high correlations were consistently observed across all variables. Therefore, we first sorted the photos based on

the naturalness ratings, which showed the highest correlation with the amount of subjective wood. To minimize the influence of spatial type, we limited the selection to samples resembling conference rooms or similar office places, while also ensuring the naturalness values were evenly distributed. The wood ratio in the six photos ranged from 0 to 77%.

Measures

Participants rated the same survey items as in Study 1. Each stimulus was rated using 5-point bipolar scales where 3 equaled neutral. In addition to the NEP scale and 13 items regarding awareness of the environment and wood use, we used the short version of the NR scale [31]. The 6 items of this scale were translated by the authors. Participants were asked to rate on a 5-point scale (1 = strongly disagree to 5 = strongly agree). The score of the NR scale was calculated by averaging the 6 items.

Participants were also asked to report their willingness to pay for wood interiors (*“Do you think it is acceptable to use wood for the interior of your home/office, even if it increases the cost?”*). Participants responded on a 7-point scale (1 = I don't want to use wood, 2 = I want to use it if the cost is the same, 3 = I want to use it if it becomes 20% more expensive, 4 = 40% more expensive, 5 = 60% more expensive, 6 = 80% more expensive, 7 = I want to use it if the cost doubles). Furthermore, to measure the wood use intention, we included two items (*“Would you like to use wood in the interior of your home?”* and *“Would you like to use wooden furniture in the interior of your home?”*). Participants responded on a 5-point scale (5 = definitely would to 1 = definitely would not).

Finally, three items referring to experience with nature and wood (*“In the place where you have lived the longest, how much natural environments such as a forests, groves, fields, lakes, marshes, rivers, or streams were within easy reach?”*, *“How much have you had the opportunity to come into contact with timber (such as wooden pillars or boards)?”*, and *“How much have you had the opportunity to come into contact with wooden furniture or furnishings?”*) were used. Participants rated these items on 5-point scales ranging from 5 = a great deal to 1 = not at all.

Procedure

Participants rated 6 stimuli and then completed the other items related to environmental concerns and nature-relatedness. The other procedures were the same as for Study 1.

Data analysis

We used the following packages: lavaan [50] and semPlot [51] for the structural equation modeling (SEM).

As practical fit measures for the goodness of fit, Hu and Bentler [52] proposed that the comparative fit index (CFI) and Tucker–Lewis index (TLI) should be 0.95 or higher, root-mean-square error of approximation (RMSEA) should be less than 0.06, and standardized root-mean-square residual (SRMR) should be less than 0.08. Moreover, Hu and Bentler [52] also pointed out the effectiveness of using different fit indices in combination. Thus, we used CFI, TLI, RMSEA, and SRMR to determine our model fit.

Results

The NR scale

The mean of the NR scale was 2.95 ($SD=0.82$, $Min.=1$, $Max.=5$). This mean value was similar to or slightly lower than that of the original study [31]. In the original study, four studies were conducted, and six means were reported, which ranged from 3.00 ($SD=0.86$) to 3.56 ($SD=0.95$). Cronbach's α for the NR scale indicated high internal consistency ($\alpha=0.85$ [95% CI 0.83, 0.87]).

Factor analysis using the NEP scale, NR scale, and other items

First, we conducted an exploratory factor analysis using a total of 34 items, including the NEP scale, the NR scale, and items about attitudes toward the environment and use of wood. Regarding the NEP scale, even-numbered items were not reversed. Given that the results of Study 1 suggested the two-factor structure of *Ecocentric* and *Anti-Anthropocentric*, we thought it would be easier to understand if the even-numbered items were not reversed and were considered to indicate the *Anthropocentric* orientation. Based on the MAP criterion and the result of the parallel analysis, we assumed a five-factor structure. Factor loadings and communalities of the factor analysis are shown in Table 5.

As seen in Table 5, the items corresponding to *Ecocentric* of the NEP scale had high factor loadings. Slightly lower loadings on Factor 1 were confirmed for the items asking about interest in forests and environmental issues. Thus, Factor 1 can be considered a general pro-environmental attitude. Factor 2 corresponded to the NR scale and was moderately correlated ($r=0.46$) with Factor 1. Nature-relatedness can be interpreted as an internalization of pro-environmental attitudes. For Factor 3, the items related to the use of wooden products by others around you or you were also highly correlated with Factor 2 ($r=0.68$). Factor 4 corresponded with the anthropocentrism of the NEP; simultaneously, the factor loadings on Factors 1 and 2 were low for the items asking about humans' right to alter nature. Thus, this factor can be interpreted as an affirmation of management to maintain and protect the environment, rather than the dichotomy between humans and nature as initially assumed. Finally,

Table 5 Factor loadings and communalities of exploratory factor analysis using all items, including the NEP and the NR scales

Item	Factor loading					Communality	
	1	2	3	4	5		
F1: General pro-environmental attitude							
NEP5	Humans are severely abusing the environment	0.79	-0.04	-0.12	-0.05	-0.04	0.56
NEP15	If things continue on their present course, we will soon experience a major ecological catastrophe	0.73	-0.02	-0.07	-0.03	0.04	0.49
NEP13	The balance of nature is very delicate and easily upset	0.73	-0.12	-0.05	-0.01	0.02	0.44
NEP3	When humans interfere with nature it often produces disastrous consequences	0.67	-0.07	0.02	-0.10	-0.08	0.43
NEP7	Plants and animals have as much right as humans to exist	0.66	-0.05	0.05	-0.02	-0.06	0.43
NEP1	We are approaching the limit of the number of people the earth can support	0.61	-0.05	-0.03	-0.07	0.04	0.33
NEP11	The earth is like a spaceship with very limited room and spaces	0.57	0.03	-0.03	0.04	0.00	0.33
E5	I think it is good to use thinned wood to protect the environment [Thinned wood] Wood that is made from trees that have been felled to reduce over-crowding in order to maintain a healthy forest	0.55	0.01	0.00	0.01	0.08	0.32
E3	I am interested in protecting forests	0.52	0.34	0.08	-0.13	0.01	0.59
E2	I know about SDGs	0.45	0.06	0.12	-0.03	0.07	0.30
NEP4	Human ingenuity will insure that we do NOT make the earth unlivable	0.43	-0.11	0.06	0.38	-0.01	0.34
E1	I am interested in environmental issues	0.42	0.32	0.11	-0.11	0.09	0.51
E4	I think it is good to use wood to protect the environment	0.37	0.21	0.05	0.10	-0.07	0.30
F2: Nature relatedness							
NR3	My connection to nature and the environment is a part of my spirituality	-0.09	0.92	-0.10	0.01	-0.01	0.67
NR2	I always think about how my actions affect the environment	-0.04	0.83	-0.04	0.00	0.03	0.64
NR6	I feel very connected to all living things and the earth	0.02	0.74	-0.06	0.03	-0.04	0.50
NR5	My relationship to nature is an important part of who I am	0.04	0.71	0.05	0.01	-0.08	0.54
NR4	I take notice of wildlife wherever I am	-0.11	0.67	0.06	0.02	0.03	0.48
NR1	My ideal vacation spot would be a remote, wilderness area	0.26	0.41	0.00	-0.03	-0.06	0.30
F3: Use of wood products							
E8	Your family or close friends actively use wood products	-0.07	-0.06	0.96	0.02	-0.08	0.76
E9	Your acquaintances actively use wood products	-0.08	-0.07	0.91	0.07	-0.03	0.73
E7	I actively use wood products in my daily life	0.00	0.07	0.73	-0.03	-0.03	0.56
E10	I have experience making things using wood outside of school classes	0.13	0.02	0.40	-0.04	0.09	0.26
F4: Anthropocentrism							
NEP12	Humans were meant to rule over the rest of nature	-0.20	0.10	-0.04	0.66	0.02	0.47
NEP10	The so-called "ecological crisis" facing humankind has been greatly exaggerated	-0.12	-0.01	-0.02	0.60	0.02	0.34
NEP2	Humans have the right to modify the natural environment to suit their needs	0.03	-0.09	0.07	0.59	-0.05	0.34
NEP14	Humans will eventually learn enough about how nature works to be able to control it	-0.20	0.01	0.08	0.57	-0.01	0.36
NEP9	Despite our special abilities humans are still subject to the laws of nature	-0.01	0.08	-0.04	0.56	-0.02	0.33
NEP6	The earth has plenty of natural resources if we just learn how to develop them	0.27	-0.07	-0.01	0.48	-0.02	0.30
NEP8	The balance of nature is strong enough to cope with the impacts of modern industrial nations	0.26	0.07	-0.09	0.35	0.06	0.23
F5: Awareness of forest certification							
E12	I know the meaning of this mark	0.05	-0.07	-0.10	-0.03	1.02	0.87
E11	I have seen this mark before	0.11	-0.12	-0.03	-0.06	0.71	0.40
E13	When purchasing products, I pay attention to the display of certification marks like this	-0.09	0.16	0.02	0.01	0.60	0.49
E6	I have experience in activities related to forest protection (e.g., volunteering for tree planting and forest development)	-0.18	0.12	0.14	0.13	0.37	0.35
F1		-	0.46	0.34	0.15	0.01	
F2		-	-	0.67	0.36	0.49	
F3		-	-	-	0.35	0.54	
F4		-	-	-	-	0.29	
F5		-	-	-	-	-	

Table 5 (continued)

Note. $N=737$. Maximum likelihood method with a promax rotation was used. Even-numbered items are reversed items. Factor loadings above 0.30 are in bold. Cronbach's α of NR scale was 0.85 [95% CI 0.83, 0.87]

Factor 5 was related to the awareness of the forest certification logo, which was linked with nature-relatedness ($r=0.49$) and the use of wood products ($r=0.54$).

Examination of the relationship between environmental attitudes and behavioral aspects

Next, we examined the relationship between environmental attitudes and behaviors. Based on the results of the factor analysis, latent variables were assumed, with the items corresponding to each factor (items with absolute values of 0.2 or greater) as observed variables in a path analysis conducted using SEM. In the SEM, experiences of contact with nature and wood, preference for wooden environments, intention of wood use, and willingness to pay were all used as factors in the analysis. Because annual household income is a critical variable in this study, we excluded 194 respondents who reported not knowing their income from the analysis. To ensure equal interval spacing among response options for the question on cost for wooden interiors, participants who selected 1 = I don't want to use wood (home $N=53$, office $N=60$) were excluded. Consequently, SEM analysis used data from 482 respondents. All demographic variables were initially included; no significant paths existed in the model for gender, whether the respondent had children or not, and whether the respondent lived in a metropolitan area. Only age and annual household income had a significant path for other latent variables retained in the model. Based on the TRA theoretical framework, we first assumed a sequential model of attitude \rightarrow intention \rightarrow behavior. Furthermore, we considered several factors in constructing the model: first, past experiences and demographics possibly influence attitude [29, 53]; second, the more specific environmental attitude such as NR may have greater explanatory power than the general pro-environmental attitude [54]; third, knowledge about forest certification may be considered to be more directly linked to intention or behavior [55]; and fourth, current wood use behavior may be linked to willingness to pay (WTP), which can be considered a future wood use behavior. Furthermore, although prior research [56] has not demonstrated the influence of income, we considered it necessary to include the possibility that annual income may somewhat affect the intention of wood use and WTP.

Referring to the modification index, we added correlations between the errors of the observed variables, assuming latent variables. From the value of the fit statistic, this model is considered to fit the data (CFI=0.956,

TLI=0.950, RMSEA=0.028 [90% CI : 0.024, 0.031], SRMR=0.049). The structural model with these two observed variables, standardized estimates (β) and coefficients of determination (R^2), is shown in Fig. 2. The results for the latent structural variables are also shown in Table 6.

All estimates were significant at the 95% level. Figure 2 shows that the observed variable, age, was positively associated with a general pro-environmental attitude ($\beta=0.27$) and prior experiences with nature and wood ($\beta=0.11$). A richer experience was associated with higher pro-environmental attitudes ($\beta=0.42$), nature relatedness ($\beta=0.26$), and more use of wood products ($\beta=0.41$), but also with lower awareness of forest certification ($\beta=-0.25$). Both a pro-environmental attitude ($\beta=0.28$) and anthropocentrism ($\beta=0.38$) were significantly associated with nature relatedness. The path from anthropocentrism to the use of wood products was also significant ($\beta=0.15$). A higher general pro-environmental attitude was associated with higher nature relatedness ($\beta=0.28$) and intention to use wood ($\beta=0.36$), but also with lower awareness of forest certification ($\beta=-0.27$) and preference for wooden environments ($\beta=-0.17$). The estimate of the path from nature relatedness to the use of wood products was relatively high ($\beta=0.57$), and the estimate of the path from the use of wood products to awareness of forest certification was even higher ($\beta=1.00$). More use of wood products ($\beta=0.58$) and lower awareness of forest certification ($\beta=-0.44$) were associated with a higher intention to use wood. The path from household income to the intention to use wood was significant, although the value was relatively small ($\beta=0.09$). Finally, awareness of forest certification ($\beta=0.39$) and intention ($\beta=0.23$) were positively associated with the willingness to pay for the wooden interior, while the preference for wooden environments ($\beta=-0.15$) and anthropocentrism ($\beta=-0.15$) were negatively associated with the willingness to pay.

Discussion

In Study 2, the results of the factor analysis using the NEP scale, NR scale, and items that asked about attitudes toward the environment and use of wood indicated that each factor corresponded to the original scale except for the factor of a general pro-environmental attitude; the factors were interpretable. Furthermore, SEM revealed the psychological processes among prior experiences, attitudes, intentions, and willingness to pay regarding the use of wood. In short, experiences had direct

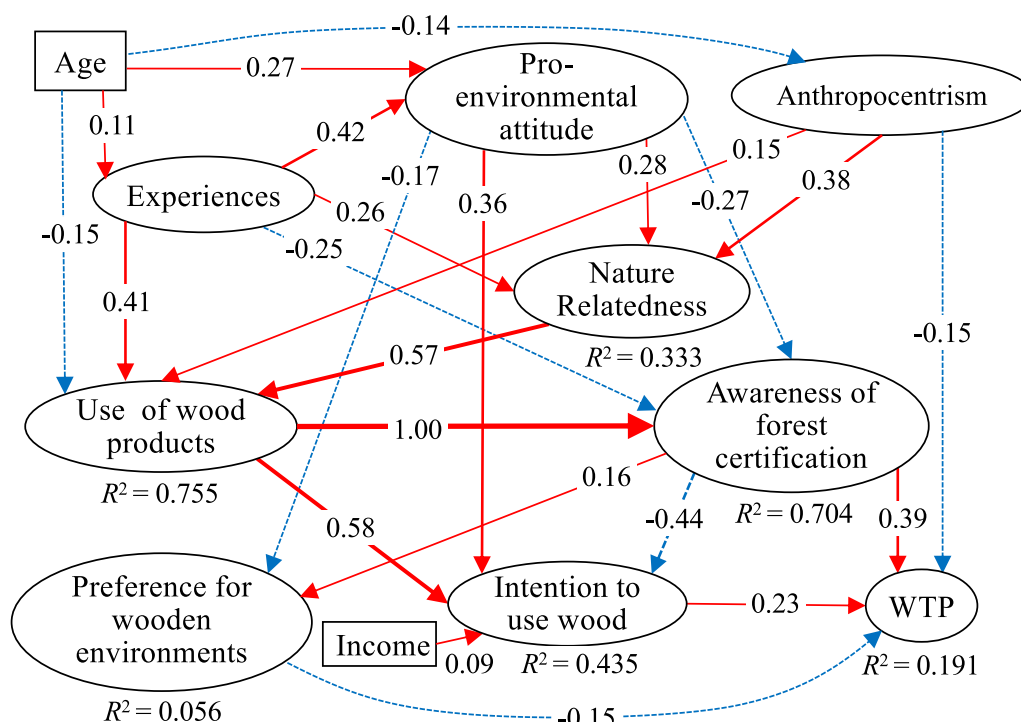


Fig. 2 Structural equation model predicting willingness to pay for wooden interiors. $N=482$. Statistics are standardized estimates. The variables enclosed in circles are latent variables, and the observed variables corresponding to each latent variable are not shown for clarity. Solid red lines represent significant positive relations; dotted blue lines represent significant negative relations

relationships with the use of wood products and a pro-environmental attitude. When pro-environmental attitudes were internalized as nature relatedness, nature relatedness had a greater impact on the use of wood. The correlation between NEP and NR aligns with prior research [30]. The environmental attitudes measured in this study represent a more general and broad world view encompassing NEP, while NR is considered a more limited personal attitude focused on the relationship between the environment and the self. The results are consistent with prior research [54] that has indicated that general pro-environmental attitudes do not predict recycling behavior, whereas attitudes limited to recycling do predict recycling behavior. This suggests the importance of using NEP in conjunction with the NR scale. Furthermore, the intention to purchase mediated the relationship between the current use of wood products and WTP, and the influence of income was relatively small.

Moreover, the use of wood products had a relatively strong relationship with awareness of forest certification. Prior studies have consistently indicated the importance of environmental knowledge on environmental behavior intention and ecological behavior [55]. A more recent study revealed that objective knowledge

of plastic recycling predicted recycling behavior [57]. In this case, through the daily use of wood products, people gained knowledge about wood, especially about forest certification; this knowledge could influence the willingness to pay for wooden environments. The path from awareness of forest certification to intention to purchase was negative, which may be related to the lack of information on forest certification when asking about the intention to use wood for interior decoration and furniture.

In Study 2, to capture behavioral indicators, we asked respondents about their willingness to pay for wooden environments. The term *cost* in the question was designed to refer to the relative cost compared to not using wood, not to an increase in wood prices. However, since respondents were only presented with the question “Do you think it is acceptable to use wood for the interior of your home/office, even if it increases the cost?”, it is unclear whether they understood “cost” as the relative cost compared to not using wood, an increase in the price of wood itself, or whether it referred only to the initial installation cost or also included ongoing costs such as maintenance fees. Future research should clarify this distinction.

Table 6 Results for the structural variables in the SEM model

Variable	B	SE B	95% CI for B		β
			LL	UL	
Experiences \leftarrow age	0.005*	0.002	0.00	0.01	0.106
Pro-env \leftarrow age	0.010***	0.002	0.007	0.014	0.269
Anthropocentrism \leftarrow age	-0.007**	0.003	-0.013	-0.002	-0.140
Wood use \leftarrow age	-0.007***	0.002	-0.010	-0.003	-0.149
Pro-env \leftarrow experiences	0.347***	0.053	0.244	0.451	0.415
NR \leftarrow experiences	0.147***	0.038	0.072	0.221	0.257
Wood use \leftarrow experiences	0.406***	0.061	0.286	0.527	0.406
Awa FC \leftarrow experiences	-0.329**	0.100	-0.525	-0.133	-0.253
NR \leftarrow anthropocentrism	0.187***	0.036	0.116	0.258	0.375
Wood use \leftarrow anthropocentrism	0.129**	0.041	0.049	0.209	0.148
NR \leftarrow Pro-env	0.188***	0.045	0.099	0.277	0.275
Intention \leftarrow Pro-env	0.456***	0.100	0.261	0.652	0.357
Awa FC \leftarrow Pro-env	-0.417***	0.095	-0.603	-0.230	-0.268
Preference \leftarrow Pro-env	-0.073*	0.031	-0.134	-0.011	-0.167
Wood use \leftarrow NR	1.006***	0.172	0.669	1.343	0.574
Awa FC \leftarrow wood use	1.295***	0.138	1.024	1.567	0.997
Intention \leftarrow wood use	0.620***	0.150	0.327	0.914	0.580
Intention \leftarrow Awa FC	-0.359**	0.109	-0.572	-0.146	-0.436
Intention \leftarrow income	0.037*	0.017	0.005	0.069	0.093
Preference \leftarrow Awa FC	0.045*	0.020	0.005	0.085	0.160
WTP \leftarrow Awa FC	0.392***	0.072	0.251	0.533	0.389
WTP \leftarrow intention	0.285***	0.069	0.150	0.421	0.233
WTP \leftarrow preference	-0.528*	0.261	-1.039	-0.017	-0.146
WTP \leftarrow anthropocentrism	-0.167*	0.072	-0.308	-0.027	-0.146

$N = 482$. Awa FC = awareness of forest certification, NR = nature relatedness, Pro-env = general pro-environmental attitude, Wood use = use of wood products, Preference = preference for the wooden environments, Intention = intention to purchase the wooden environments.

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

General discussion

The present study sought to reveal the influences of environmental attitude on preference for wooden environments (Study 1) and the relationship between environmental attitude and behavior related to the use of wood (Study 2) by the public in Japan. Using 20 photos of wooden living spaces, Study 1 demonstrated that environmental attitude does influence preferences. Study 2 confirmed this effect in six of these photos, and the SEM showed the relationship between experiences, attitude, intention, and willingness to pay regarding the use of wood. Attitude was not associated with wood use behavior, and wood use was not associated with willingness to pay. However, when the factors of nature relatedness and intention to purchase were accounted for, it was possible to interpret the relations from attitude to a future willingness to pay. These results are consistent with Ajzen's TRA [21], which states that attitudes explain behavior through intentions.

In this study, nature relatedness was related to the use of wood products; simultaneously, knowledge of forest certification was related to willingness to pay for wooden interiors. These results suggest the importance of focusing on policies that provide knowledge that leads to willingness to pay, such as forest certification. While it is difficult to confirm the origin and fairness of the wood products themselves that are on display in stores, consumers can use the forest certification mark to determine whether the wood products come from a properly managed forest. For people to recognize that products made from wood from managed forests are worthwhile, even if they are more expensive, further research is needed to promote the knowledge of forest certification and the carbon absorption function of forests. To achieve more effective results, including nature conservation, it will be necessary to promote the use of products with forest certification marks even more than before, rather than simply using wood products.

In Studies 1 and 2, NEP and pro-environmental attitudes had a negative, though modest, effect on preferences for wooden environments and awareness of forest certification. Increasing general environmental concerns does not necessarily result in a preference for wooden spaces or greater wood use. For instance, when awareness of the need for human intervention to maintain healthy forests is low, showing a high NEP score or strong pro-environmental attitudes may lead to an overtly preservationist perspective that views any human intervention in nature as inherently negative. From this perspective, even the use of wood may be perceived as a harmful intrusion, potentially reducing preference for wooden living environments. Therefore, efforts to strengthen general environmental attitudes should be considered carefully, as they may inadvertently discourage preference for wooden environments and wood use.

Considering the Japanese view of nature, the NEP—based on the Western mindset of humans confronting nature as taught in the Bible—may struggle to incorporate the Japanese perspective that sees humans as existing within nature. However, while keeping this point in mind, we believe it is meaningful to explore people's thoughts using the same scale. The fact (confirmed in this study) that NR, which measures the relatedness between the natural environment and humans, has a greater influence than NEP, might also reflect the nature of the Japanese view of nature.

This study, intended for the general Japanese public, was conducted through a survey company, which oversaw participant recruitment and data collection. Therefore, there may be a concern about bias in the sample. One characteristic that distinguishes participants in this study from the general population is their motivation to answer surveys as monitors. However, as seen in the results of Study 1, when comparing NEP scores between this study and previous research, participants did not appear to have a higher environmental attitude or interest toward wood compared to the general population. In the future, a method that targets a wider sample should be incorporated. This study classified residential areas as metropolitan or non-metropolitan areas at the prefectural level. However, cities within the same prefecture vary in population size urbanization, which may influence awareness of nature. For example, a study of university students in Spain and Ecuador [58] reported a significant effect of residential location (town, city, and countryside) on connection with nature, while a study of children in urban and suburban schools in China [59] did not find a significant effect, indicating inconsistent results. Future research should analyze at the city level to examine the effects of urbanization more precisely.

Conclusion

Our study reveals the impact of environmental concerns on the preference for wooden living spaces, emphasizing the need to foster nature connections and educate individuals about forest certification systems to promote sustainable wood use.

While the relationship between attitudes and behavior has been examined within the recycling and climate change context, and the influence of values and environmental attitude has been noted, research comprehensively modeling the impact of attitudes on wood use settings has been lacking. Despite limitations, this research contributes significantly to the literature by demonstrating the importance of considering environmental attitudes and intention to understand the comprehensive relationship between preference for wooden environments and wood use behavior within the TRA framework.

Abbreviations

CFI	Comparative fit index
CI	Confidence interval
MAP	Minimum average partial
NEP	New environmental/ecological paradigm
NR	Nature relatedness
RMSEA	Root mean square error of approximation
SD	Standard deviation
SEM	Structural equation modeling; SGE: Sustainable Green Ecosystem Council
SRMR	Standardized root-mean-square residual
TLI	Tucker–Lewis index
TRA	Theory of reasoned action; WTP: Willingness to Pay

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Author contributions

Yui Motoyama: conceptualization, methodology, formal analysis, data curation, writing—original draft, review and editing, funding acquisition. Seiichiro Ukyo: methodology, writing—review and editing. Takeshi Morikawa: methodology, writing—review and editing. Kazunori Hanyu: conceptualization, methodology, formal analysis, writing—review and editing.

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Data availability

The data used and analyzed in this study will be made available upon reasonable request. Point of contact: Yui Motoyama (motoyama_yui670@ffpri.go.jp).

Declarations

Ethical approval and informed consent statements

This study was conducted with the approval of the research ethics committee of the authors' affiliated institute (Permit No. 22M-7 on December 15, 2022). The survey form included details about its purpose, and respondents' completion of the questionnaire was considered implied consent to participate.

Consent for publication

Not applicable.

Competing interests

The authors have no conflicts of interest to disclose.

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