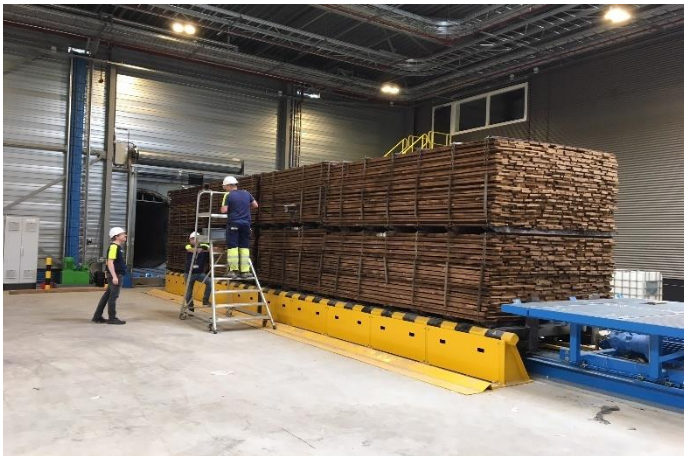
9th European Conference on Wood Modification

ECWM9

September 17 and 18, 2018, Arnhem, The Netherlands

PROCEEDINGS



SHR

ECWM9
The 9th European Conference on **Wood** Modification
The Netherlands • Arnhem • September 17-18, 2018

PROCEEDINGS

9th European Conference on Wood Modification

Burgers' Zoo

Arnhem, The Netherlands

17-18 September 2018

In association with:

COST FP1407 ModWoodLife

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Preface

SHR was one of the first research institutes in Europe, who already in the 1990´s did substantial research work to develop wood modification processes. It appeared, that this research area was very complex, and that for a successful application of potential processes different expertise's was needed. A good network between research partners and industry was needed and the "European Network on Wood Modification" was created. 15 years ago, in 2003, the first European Conference on Wood Modification "ECWM" was held to present the outcomes of this EU financed network. Since than, ECWM´s were held each 2-3 years at different places around Europe, and now we can celebrate the 9^{th} ECWM in the Netherlands, organized by SHR where it all began.

As already before, ECWM 9 is linked up to the European COST organisation. Thanks to the COST Action FP 1407 ModWoodLife to join and strengthen our network!

The participation of researchers of all around the world make it obvious that the name "European conference" is much too small…so: a warm welcome to researchers from industry and academia from Europe and abroad! This success has led, once again, to a large number of abstracts submitted to the organizers. In general, these abstracts were of a high quality and the members of the Scientific Committee had a hard time to select 44 full presentations and 50 poster presentations out of the many applications. We hope we have found the right balance between scientific and applied presentations to reach the key goal of ECWM: to attract researchers from academia and industry to join their expertises in this very exciting research area "wood modification".

The local conference organizers from SHR have done a great job this past year to make us feel welcome in The Netherlands and to let the conference be a success. Thank you very much to Bôke and team!

Prof. Dr. Holger Militz
Chairman of Scientific Committee
Georg-August-University Göttingen, Germany

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Mrs. Jos Gootjes, SHR	SHR; The Netherlands

Wood modification in practice

The European Conference on Wood Modification takes place on the 17th and 18th of September 2018 in Arnhem, The Netherlands and is organised by SHR. At this conference researchers and people from industry from all over the world will come together to share their knowledge and experiences with the latest developments on wood modification methods, applications and products. The conference was given the subtitle “Wood modification comes home”, which refers to the role The Netherlands and SHR have played – and still play – in the development and industrial application of modified wood.

Techniques and methods designed for improving wood properties are almost as old as mankind itself. However the scientific and industrial rise of wood modification became significant under the influence of a number of social and economic developments in the eighties and nineties of the previous century. A strong need was felt to find alternatives for the use of tropical hardwoods and preservative treated wood, which were both under pressure for a variety of reasons. The discussions regarding a clean environment, sustainable forest management, wood use and the increasing wood demands from emerging markets in Asia also had a big impact. Wood modification was recognized to have the ability to offer a more, better and sustainable way of making use of wood as a durable material in a broad range of applications. Besides that, it was found to be a supreme method for upgrading the properties of lesser used timber species and to provide technical solutions to overcome some of the natural deficiencies of wood as water uptake, decay and dimensional changes.

Over the last decades an enormous amount of scientific work has been performed and published. We have seen many innovative modification ideas, methods and techniques passing by during the previous eight ECWM’s. To make a real impact, ideas need to be developed further and put into practice. We are proud that in The Netherlands we have created a setting with a high level of knowledge, innovative thinking combined with entrepreneurship, which lead to a variety of flourishing companies involved in industrial production of modified wood. Not only producing companies, but also the wood processing industry has adopted modified wood as a highly appreciated durable material. We can declare that modified wood has become a lasting factor in the wood processing industry.

For these reasons SHR and we as the organising team, are excited to welcome you all here in The Netherlands for the 9th European Conference on Wood Modification. We hope you will enjoy your stay here in Arnhem and become inspired by all attendees, presenters and new insights this conference has to offer.

Welcome!

The organising team

COST 1407 - Foreword

It is our pleasure that COST Action FP1407 “Understanding wood modification through an integrated scientific and environmental impact approach” (ModWoodLife) in part of 9th European Conference of Wood Modification. The conference brings together researchers from across Europe and beyond that jointly are addressing the mounting pressure on renewable resources (as a material source, for recreational, ecological, and other uses). By maximising the efficiency of materials derived from them, the wood modification community plays an important role. The efficiency can only be achieved if new methods to improve the functionality, durability, properties, and environmental impacts will be developed. Wood modification addresses these requirements directly, allowing wood to be used in more applications, including increased use of under-utilised species. Wood modification also addresses undesirable characteristics of wood such as fungal resistance, UV-stability, and moisture sensitivity. The COST Action FP1407 has been successful in addressing these needs in the past 3 years. We are in the last year of the Action and therefore it is even more important for us to be at ECWM9. Only sustainable collaboration and joint efforts will deliver the impacts. That objective of the Action FP1407, to characterise the relationship between wood modification processing, product properties, and the associated environmental impacts in order to maximise sustainability and minimize environmental impacts, has great value for the forest sector, for researchers, and society at large.

Wishing you a successful and memorable conference full of fruitful discussions.

Andreja Kutnar
Chair, COST FP1407

Denis Jones
Vice-Chair, COST FP1407

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Perception and evaluation of modified wood

Dean Lipovac, Michael D. Burnard[2] and Andreja Kutnar[3]

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Keywords: evaluation, perception, preference, tactile, visual, wood modification

ABSTRACT

Wood modification processes improve many characteristics of wood that are appreciated among building professionals. The same modification processes also change characteristics of wood that are important to laypeople, such as wood's visual (e.g., colour) and tactile (e.g., roughness) properties. Since these properties are crucial in people's perception and evaluation of materials, it is necessary to study how people perceive and evaluate modified wood. To assess human perception and evaluation of modified wood compared to untreated wood and steel, we prepared six cylindrical handrail samples. They were from unmodified spruce, unmodified pine, acetylated radiata pine, thermally modified spruce, thermally modified pine or stainless steel. 50 participants aged 65 or above rated all samples in random order on a 9-item semantic differential scale, which consisted of sensory (e.g., rough-smooth) and evaluative (e.g., like-dislike) pairs of descriptors. The study consisted of a tactile only task, visual-tactile task, and ranking task. The results indicate that modified wood is perceived and evaluated similarly to untreated wood both in the tactile and the tactile-visual task, while the stainless steel was perceived as considerably different than all types of wood. Ratings of the same handrails between the tactile and the tactile-visual task were similar, which suggests that touch has an important role in perception and evaluation of materials. The two highest ranked handrail samples were both manufactured from modified wood. Taken together, the findings indicate that modified wood possesses tactile and visual features that are comparable to untreated wood and are in general liked among older adults. These findings encourage the use of wood in indoor environments.

INTRODUCTION

Wood modification processes, such as thermal modification, can enhance several characteristics of wood including dimensional stability, durability against decay, and increased resistance against fungi and insects (Sandberg *et al*. 2017). Since these enhancements are useful in the construction field, it is not surprising they are valued among building professionals. However, modified wood does not obtain only transformed mechanical, biochemical and thermal properties, but also qualities that are available directly to our senses, such as colour, dryness or roughness (Bakar *et al*. 2013, Esteves and Pereira 2009). The combination of these basic sensory properties plays an important role in the general evaluation of materials by laypeople, where characteristics such as pleasantness, price, naturalness, and others are assessed (Fujisaki *et al*. 2015, Kidoma *et al*. 2017).

Better evaluated materials are not only more attractive to consumers, but can also provide direct health benefits. Based on the tactile information, wood is evaluated more favourably than marble, tile, and steel. In addition, subjects touching wood experience improved mood and decreased physiological arousal when compared with the tactile experience of other common materials (Ikei *et al*. 2017b). Even when the differences between materials do not seem significant, resulting perceptions and evaluations are nonetheless changed. Different coatings on the same material are enough to produce distinct evaluations and physiological reactions (Bhatta *et al*. 2017, Ikei *et al*. 2017a). For instance, subjects touching uncoated wood rated it as more natural than wood with either oil, vitreous, urethane or mirror finish. A mirror-finished wood sample was in general rated as the least favoured and was the only material in the study to induce an undesirable increase in physiological arousal (Ikei *et al*. 2017a). Along with the tactile qualities, visual characteristics of materials also play an important role in the evaluation of materials. For example, brighter samples of wood are perceived as more new and relaxing, but less interesting than darker materials (Fujisaki *et al*. 2015). Additionally, visual exposure to a wood panel induces improved mood and a decrease in physiological arousal, while watching a steel panel produces the opposite effect (Sakuragawa *et al*. 2005).

Taken together, current findings suggest that physical qualities of materials significantly influence human perception and evaluation, which is, in turn, associated with changes in mood and physiological states. Therefore, to be able to choose and develop appealing and healthy materials, it is important to assess how people perceive and evaluate them. Since modified wood exhibits several advantages over untreated wood, it seems reasonable to predict that its usage will keep increasing over time. However, it is not known how people perceive and evaluate wood that undergoes modification processes. Investigating this will lead us towards creating new materials that are not only valuable in construction, but also attractive and healthy for everyday users. This is especially important in the indoor environments occupied by aging individuals, whose physical abilities may be limited, which often results in a need for supportive/assistive elements of the environment. One of the features that can significantly contribute to the physical mobility of older adults is the availability and suitability of support rails and handrails.

Our study assessed how people perceive and evaluate handrails manufactured from modified wood compared to handrails produced from untreated wood and stainless steel based on touch alone in addition to touch and vision combined. Furthermore, we examined which sensory tactile and visual characteristics (e.g., roughness, lightness) are associated with general evaluation and preference of the materials. Finally, we investigated perception and evaluation of the same materials between the tactile and the tactile-visual task.

EXPERIMENTAL

Handrail samples

To investigate perception and evaluation of modified wood we prepared six cylindrical handrail samples. One sample was produced from stainless steel, while the remaining five were manufactured from either untreated or treated spruce or pine. Specifically, we included unmodified spruce, unmodified pine, acetylated radiata pine, thermally modified spruce, and thermally modified pine. The thermal modification was done with the commercial ThermoD process at 212°C and superheated steam at Heatwood (Hudiksvall, Sweden). Handrail samples measured 42mm in diameter and were 30cm long. Each sample was mounted on a wooden base covered with white foil measuring approximately 30 x 15 x 5 cm. All six samples are presented below (Figure 1).

Figure 1: Handrail samples (from left to right: unmodified spruce, unmodified pine, acetylated radiata pine, thermally modified pine, thermally modified spruce, stainless steel)

Procedure

The study consisted of three parts. In the first part, participants separately rated each handrail sample by touch only – they were instructed to keep their eyes closed (tactile task). Samples were presented to them in random order. For each handrail, subjects provided a verbal answer for each item on a semantic differential scale that was read to them. In the second part of the study, participants rated the samples again in the same order, except they were able to both touch and see the handrails (tactile-visual task). In the third part, the participants were presented all the samples at once to simultaneously see and touch. They were asked to rank them from the most to least preferred by placing cards numbered from one (preferred) to six (least preferred).

Semantic differential scale

The scale was partly based on the descriptors of the Tactile Perception Task (TPT; Guest *et al*. 2011) that were translated to Slovene. TPT assesses both sensory (e.g., dry) and evaluative (e.g., pleasant) aspects of touch. Some descriptors in the TPT were excluded since they were judged as inappropriate for the assessment of chosen materials (e.g., sensual). We also excluded descriptors that were similar in meaning to already adopted descriptors (e.g., we excluded "enjoyable" due to already including "pleasant"). To each descriptor that remained, we added a polar opposite descriptor and ended up with five word pairs (e.g., pleasant – unpleasant). In addition to the descriptors adopted from the TPT, we included one pair of tactile descriptors (soft – hard) and two pairs of visual descriptors (dark – light, shiny – matte) that were used in other studies (e.g., Fujisaki *et al*. 2015) and deemed relevant. Furthermore, we added three relevant pairs of evaluative descriptors (unusual – usual, natural – artificial, cheap – expensive). In total, the scale consisted of 11 word pairs. Two of these (dark – light, shiny – matte) were used only in the second part of the study (tactile-visual task). Six of 11 pairs of descriptors measured basic sensory properties (rough – smooth, warm – cold, dry – damp, hard – soft, dark – light, shiny – matte) while the remaining five measured the evaluation of materials (unusual – usual, natural – artificial, cheap – expensive, pleasant – unpleasant, dislike – like). For each word pair, subjects selected their answer from a 5-point scale that consisted of the adverbs "considerably", "somewhat", "in the middle", "somewhat" and "considerably". For example, on a "rough – smooth" pair, subjects could indicate that the rated sample is "considerably rough", "somewhat rough", "in the middle", "somewhat smooth" or "considerably smooth". The complete scale is presented below (Table 1).

Table 1: Semantic differential scale

	Considerably	Somewhat	In the middle	Somewhat	Considerably	
Rough	-2	-1	0	1	2	Smooth
Warm	-2	-1	0	1	2	Cold
Dry	-2	-1	0	1	2	Damp
Soft	-2	-1	0	1	2	Hard
Unusual	-2	-1	0	1	2	Usual
Natural	-2	-1	0	1	2	Artificial
Cheap	-2	-1	0	1	2	Expensive
Pleasant	-2	-1	0	1	2	Unpleasant
Dark[a]	-2	-1	0	1	2	Light[a]
Shiny[a]	-2	-1	0	1	2	Matte[a]
Dislike	-2	-1	0	1	2	Like

[a]Only used in the tactile-visual task

Participants

The participants were invited to the study and tested in an activity centre for older adults located in Koper, Slovenia. Invited subjects had to be at least 65 years old and possess no health impairments that would interfere with the study protocol (e.g., heavily impaired vision). Subjects were not given any incentives for participation. Approximately 15% of the approached subjects chose to participate in the study. Before beginning testing, each subject signed an informed consent document to participate in the study. Altogether, 50 persons over the age of 65 (M = 72.02, SD = 6.36) took part in the study, of those 27 (54%) were women. Participants were tested in a room with no natural lighting – the amount of indoor light was thus fixed and similar for all participants. The duration of the test was approximately 30 minutes.

RESULTS AND DISCUSSION

We separately present results from the tactile, tactile-visual, and ranking task. In addition, we report correlations between descriptors within each – tactile and tactile-visual - task. Finally, we present correlations among the same descriptors between the tactile and tactile-visual task.

Mean scores and standard deviations for all pairs of descriptors and handrail samples in the tactile task are presented below (Table 2). The scores range from -2 (e.g., considerably rough) to 2 (e.g., considerably smooth). The scores of perceived warmness, dryness and softness are similar among all wooden handrails – they were perceived as somewhat warm, dry, and soft. Handrails created from modified wood were perceived as somewhat smooth, while the untreated handrails were perceived as slightly rougher. Wooden handrails were all perceived as neither cheap or expensive and somewhat/considerably usual, natural, pleasant and liked. Steel was on average perceived as smoother, colder, damper, and harder than wood (Table 2). In addition, it was evaluated as less natural, pleasant and liked, as well as slightly more expensive and unusual.

Table 2: Tactile task scores – M(SD)

	Spruce	Pine	A.Pine	T.M.Pine	T.M.Spruce	Steel
Rough (-2) – Smooth (2)	-0.66	-0.08	1.4	0.54	1.06	1.78
	(0.98)	(0.92)	(0.81)	(1.01)	(1.04)	(0.62)
Warm (-2) – Cold (2)	-0.76	-0.68	-0.74	-0.94	-1.06	1.46
	(0.87)	(0.98)	(0.88)	(0.96)	(0.87)	(0.71)
Dry (-2) – Damp (2)	-1.24	-1.36	-1.44	-1.36	-1.48	-0.56
	(0.96)	(0.80)	(0.84)	(0.88)	(0.81)	(1.51)
Soft (-2) – Hard (2)	1.00	0.88	1.08	0.76	0.96	1.8
	(1.07)	(1.12)	(1.24)	(1.36)	(1.23)	(0.73)

	Spruce	Pine	A.Pine	T.M.Pine	T.M.Spruce	Steel
Unusual (-2) – Usual (2)	1.30	1.18	1.5	1.46	1.22	0.8
	(1.34)	(1.29)	(0.86)	(0.84)	(1.15)	(1.50)
Natural (-2) – Artificial (2)	-1.34	-1.66	-1.34	-1.40	-1.5	1.08
	(1.22)	(0.82)	(1.00)	(1.07)	(1.09)	(1.54)
Cheap (-2) – Expensive (2)	-0.02	0.12	0.28	0.04	0.24	0.52
	(1.02)	(0.98)	(1.18)	(0.97)	(1.02)	(1.27)
Pleasant (-2) – Unpleasant (2)	-1.10	-1.68	-1.70	-1.54	-1.62	-0.40
	(0.97)	(0.62)	(0.58)	(0.73)	(0.70)	(1.51)
Dislike (-2) – Like (2)	0.92	1.38	1.44	1.40	1.44	0.48
	(1.21)	(0.92)	(0.86)	(0.88)	(0.93)	(1.45)

Mean scores and standard deviations for all pairs of descriptors and handrail samples in the tactile-visual task are presented below (Table 3). Scores from the tactile-visual task are similar to the scores from the tactile task. All wooden handrails were perceived as somewhat warm, dry, and soft. The perceived roughness in wooden handrails ranged from neither smooth or rough to somewhat smooth. Compared to wood, steel handrail was perceived as smoother, colder, damper and harder. All samples of wood were perceived as somewhat/considerably matte, while steel was perceived as somewhat shiny. Perceptions of darkness varied between the samples – stainless steel, unmodified spruce and pine, and acetylated radiata pine were perceived as somewhat/considerably light, while thermally modified spruce and pine were perceived as somewhat dark. All wooden samples were perceived as neither cheap or expensive, somewhat usual, somewhat/considerably natural, pleasant and liked, while the steel sample was perceived as somewhat usual, artificial, and expensive; in the middle/somewhat pleasant and liked.

Table 3: Tactile-visual task scores – M(SD)

	Spruce	Pine	A.Pine	T.M.Pine	T.M.Spruce	Steel
Rough (-2) – Smooth (2)	-0.36	0.00	1.64	0.34	1.10	1.86
	(1.08)	(1.20)	(0.75)	(1.02)	(0.99)	(0.64)
Warm (-2) – Cold (2)	-0.98	-0.92	-1.06	-1.04	-1.26	1.44
	(1.04)	(0.99)	(0.98)	(1.12)	(0.88)	(0.81)
Dry (-2) – Damp (2)	-1.42	-1.48	-1.66	-1.46	-1.62	-0.98
	(0.76)	(0.89)	(0.66)	(0.84)	(0.73)	(1.30)
Soft (-2) – Hard (2)	0.64	0.64	0.72	0.74	0.88	1.88
	(1.37)	(1.40)	(1.41)	(1.35)	(1.36)	(0.44)
Unusual (-2) – Usual (2)	1.06	1.16	1.22	1.32	1.28	0.82
	(1.32)	(1.17)	(1.17)	(1.04)	(1.07)	(1.45)
Natural (-2) – Artificial (2)	-1.66	-1.66	-1.3	-1.34	-1.34	0.98
	(0.75)	(0.87)	(1.22)	(1.32)	(1.10)	(1.57)
Cheap (-2) – Expensive (2)	-0.2	-0.10	0.06	0.04	0.32	1.02
	(1.09)	(1.20)	(1.10)	(1.09)	(1.20)	(1.08)
Pleasant (-2) – Unpleasant (2)	-1.4	-1.64	-1.52	-1.52	-1.76	-0.62
	(0.83)	(0.80)	(0.81)	(0.91)	(0.56)	(1.29)
Dark (-2) – Light (2)	1.58	1.44	1.24	-0.7	-0.96	1.24
	(0.78)	(0.70)	(0.82)	(0.84)	(0.86)	(0.87)
Shiny (-2) – Matte (2)	1.52	1.52	1.44	1.62	1.34	-1.34
	(0.93)	(0.76)	(0.84)	(0.73)	(1.06)	(0.87)
Dislike (-2) – Like (2)	1.04	1.40	1.36	1.16	1.22	0.56
	(1.21)	(0.90)	(0.92)	(1.08)	(0.89)	(1.46)

Ranking task results are presented below (Table 4). For each sample, we calculated the sum of all ranks received from participants. We reranked the samples according to these sums - the handrails with lower sums received higher rankings. The highest ranked material was thermally modified spruce, followed by acetylated radiata pine, untreated pine, and thermally modified pine. The two materials with the lowest ranking were stainless steel and unmodified spruce.

Table 4: Ranking task scores

	Spruce	**Pine**	**A.Pine**	**T.M.Pine**	**T.M.Spruce**	**Steel**
Rank	6	3	2	4	1	5

The Pearson correlation coefficients were calculated for each pair of descriptors within the tactile task (Table 5). Handrails that were rated as less liked were rated as more unusual ($r = 0.35$, $p < 0.01$), but less warm ($r = -0.36$, $p < 0.01$), dry ($r = -0.28$, $p < 0.01$), natural ($r = -0.34$, $p < 0.01$), and pleasant ($r = -0.74$, $p < 0.01$).

Table 5: Correlations among descriptors within the tactile task

	Rough	Warm	Dry	Soft	Unusual	Natural	Expensive	Pleasant	Like
Rough	-								
Warm	.28**	-							
Dry	.03	.40**	-						
Soft	.26**	.20**	-.11	-					
Unusual	.06	-.28**	-.29**	.11	-				
Natural	.24**	.56**	.30**	.14*	-.31**	-			
Cheap	.16**	.14*	.02	.16**	-.12*	.09	-		
Pleasant	-.06	.47**	.29**	.00	-.29**	.43**	.00	-	
Dislike	.11	-.36**	-.28**	.05	.35**	-.34**	.07	-.74**	-

** p < .05, ** p < .01*

The Pearson correlation coefficients calculated for each pair of descriptors within the tactile-visual task are presented below (Table 6). Handrails that were rated as less liked were also perceived as less warm ($r = -0.40$, $p < 0.01$), dry ($r = -0.30$, $p < 0.01$), natural ($r = -0.28$, $p < 0.01$), pleasant ($r = -0.67$, $p < 0.01$), and more unusual ($r = 0.34$, $p < 0.01$) and shiny ($r = 0.25$, $p < 0.01$).

Table 6: Correlations among descriptors within the tactile-visual task

	Rough	Warm	Dry	Soft	Unusual	Natural	Cheap	Pleasant	Dark	Shiny	Dislike
Rough	-										
Warm	.13*	-									
Dry	-.11	.36**	-								
Soft	.22**	.24**	-.08	-							
Unusual	.08	-.28**	-.27**	.07	-						
Natural	.21**	.56**	.24**	.22**	-.21**	-					
Cheap	.21**	.20**	-.04	.32**	.02	.21**	-				
Pleasant	.00	.49**	.38**	.08	-.38**	.40**	-.06	-			
Dark	.00	.15*	-.01	.05	-.02	.05	-.05	.06	-		
Shiny	-.34**	-.64**	-.22**	-.20**	.20**	-.57**	-.29**	-.41**	-.11	-	
Dislike	.09	-.40**	-.30**	-.04	.34**	-.28**	.07	-.67**	-.02	.25**	-

** p < .05, ** p < .01*

Correlations between the same pairs of descriptors in the tactile and the tactile-visual task are presented below (Table 7). Correlations among all descriptors between the tactile and tactile-visual task are medium to large in size. This suggests that touch plays an important role in the perception and evaluation of materials even when the materials can be examined visually.

Table 7: Correlations among the same descriptors between the tactile and the tactile-visual task

Rough	Warm	Dry	Soft	Unusual	Natural	Cheap	Pleasant	Dislike
.68**	.71**	.49**	.60**	.34*	.60**	.48**	.53**	.53**

** p < .05, ** p < .01*

CONCLUSIONS

In this study, we examined the perception and evaluation of modified wood compared with untreated wood and stainless steel. Our results indicate that modified wood is perceived and evaluated similarly as untreated wood, while the perception and evaluation of steel differs from all types of wood. Compared to steel, all types of wood received higher overall preference ratings in both the tactile and tactile-visual task. In the ranking task, wood generally received higher ranks than steel, and modified wood was on average rated higher than untreated wood. Results also indicate that touch can have an important role in the perception and evaluation of materials, as the correlation between the tactile and visual-tactile tests were very strong. Taken together, the findings of this study suggest that modified wood possesses tactile and visual features that are liked among older adults. These findings encourage further usage of modified wood in indoor environments. Using handrails manufactured from modified wood would not only decrease the usage of non-renewable materials, but also put older adults in frequent contact with the materials they prefer.

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