Effects of Material Pairs on Warmth Perception in Interiors

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Abstract. The study is the second part of a previous study which explored the effects of color pairs on warmth perception in interiors. The main aim of this study is to investigate the effects of material pairs and their single materials on warmth perception in interiors with the same methodology, since paired materials have not been investigated yet. Each material pair and their two single materials were assessed by 32 different participants, thus 96 different participants assessed three groups of material models (Fabric and Timber material pair, Fabric and Plasterboard material pair, Timber and Plasterboard material pair, and their single materials) under controlled conditions. Results indicated that as single materials Timber and Fabric have the same level of warmth and are warmer than Plasterboard whereas there is no difference between their pairs. Findings revealed that these two natural materials are perceived to be warmer than the artificial one and pairing them on interior walls provides similar level of warmth.

1. INTRODUCTION
Warmth perception, as a multisensory concept [1], defines built environment for both architects and non-architects [2]. The concept has been investigated by researchers in different disciplines [1–6]. In this study warmth perception is defined as “a physical, emotional, and sensorial bond between people and their environments” and its three aspects correspond to Desmet and Hekker’s [7] framework for product experience: “aesthetic experience correspondence physical aspects, experience of meaning correspondence semantic aspects, and emotional experience correspondence emotional aspects” which was presented in the previous report [8].

Some earlier studies focused mostly on the physical aspects ([5], according to [9]: [10]); however, more recent studies [1–3] have investigated different aspects of warmth perception in relation to both colors and materials separately. Fenko et al. [1] investigated both color effects and material effects on the perception of warmth in the context of product experience. The authors stated that figurative meaning of warmth, which is related to vision, might be underestimated during users’ product experiences while literal meaning, which is related to touch, might be overestimated [1]. Two fundamental studies [2, 3] about warmth in architectural context focused on figurative meaning as well. According to Wastiels et al. [2] surface color has more influential effect on the concept than surface roughness; however, both affect warmth perception independently. Fenko et al. [11] mentioned that dominant modality might depend on when a product has been used. For example, visual sense dominates the perception of warmth in architectural context [2].

In addition to previous studies [1–3], the recent studies [12, 13] have discussed nonphysical aspects of warmth perception and how literal and metaphorical warmth exit in design. Materials are inevitably important part of colors and surfaces which are affecting these metaphorical aspects of warmth perception. These previous studies in architecture and product design proved that materials affect warmth perception independent from their physical warmth. For both interior architecture and industrial design, materials are rarely used as single materials. There are some industrial design objects, such as some stationery items (e.g., papers) or some furniture (e.g., chairs) which only have single materials. Similarly, there are some interiors which only have single materials such as storage rooms. However, nowadays both users and designers prefer more sophisticated and complicated material palettes with two or more materials on the same surface of not only interiors but also interior walls. Nonetheless, how material pairs affect the perception of warmth in interiors have not been investigated yet. Therefore, in the current study, the researchers focused on how paired materials affect warmth perception in interiors.

1.1 Aspects of Warmth Perception
Warmth perception was analyzed according to four basic aspects: sensorial, physical, semantic, and emotional aspects [8]. As a multisensory concept [1], its sensorial aspect is based on five senses of human being [14]; however, visual sense dominates warmth perception in interiors [2]. Physical aspect consists of environments’ and/or materials’ physical features, which can be measured regardless of individual differences: thermal properties, surface properties, density, and ambient temperature [8]. Except thermal effusivity, all thermal properties; thermal conductivity, contact surface temperature, heat capacity, and initial material temperature
and warmth perception have a positive linear relationship [1–4]. Moreover, thickness, glossiness, pattern, color, and roughness are surface properties [2, 3, 15], and roughness, thickness, density, and ambient temperature have a positive linear relationship with the warmth perception [2]. According to Schifferstein and Wastiels [15] glossiness of a surface might have an effect on the perceived warmth. Although, in the context of interior architecture, there has been no agreement on the direction all of these properties' effects have, these findings still indicate the importance of materials on warmth perception in different design disciplines [1–3, 15].

The researchers embraced Brunswik's lens model [16], which was applied to environmental perception by Gifford [17]. In the light of this interpretation, actual environment corresponds physical aspects of warmth perception whereas perceived warmth includes semantic and emotional aspects [8]. The semantic aspect of the concept includes both literal and figurative meanings of warmth: actual warmth is literal meaning whereas energy and intimacy associations are figurative warmth which have more influence on the concept [1]. The previous study suggests that figurative meaning, which includes "energy" (35%) (with "active" (10%), "energized" (8%), 'excited' (8%), 'creative' (3%), 'proud' (3%), and 'healthy' (3%)" [1] connotations) and "intimacy" (35%) (with "loving" (10%), 'being together' (11%), 'atmosphere' (10%), and 'memories' (4%)" [1] connotations), are more influential than literal meaning (30%), which is related to physical properties: "physical warmth and comfort" [1]. The emotional aspect includes human social cognition with emotions, which embraces warmth as a fundamental dimension during the assessment of other individuals and other individuals' behaviors [18], whereas emotional aspects are hard to investigate without the meaning aspect [19].

In the current study, the semantic aspect was investigated in order to reveal the meanings of materials and material pairs in the context of the perceived warmth in interiors. In order to achieve that aim, all physical aspects except material types were fixed. The color (red) was fixed and three materials (fabric, timber, and plasterboard) were interchanged to explore the effects of material pairs on warmth perception in interiors.

1.2 Materials and Warmth Perception

The effects of materials on warmth perception were studied by different design disciplines such as textile, product design, and architecture. In an earlier study [20], two different types of materials’ (paper and cloth) and 11 different colors' effects on affective value and apparent warmth were investigated and their findings suggest that influence of color is higher than influence of materials' surface texture. Textile studies [21, 22] mostly focused on tactile sense while exploring material effect on warmth. One explanation of this tendency might be the scale of products in the discipline. Similarly, product design studies [1, 4, 23] probed warmth perception and tactile sense in their experimental settings; thus, both textile studies and product design studies contribute to clarify how materials and colors affect the perceived warmth in interiors. Both fabric and timber were mentioned in these previous studies. A previous study [3] investigated both visual and tactile warmth and revealed that smooth surfaces are perceived less warm than rough ones on interior walls. In addition, Wastiels et al. [2] found that technical parameters of interior wall materials are good indicators of perceived warmth. Research investigating the relationship between materials and warmth perception in the architectural context highlighted roughness as a determinant of the concept [2, 3]. Timber, as an interior material since first humans' shelters [24], is a literally warm material for tactile sense [19]. In addition, soft materials are related to “being alive” [19] and Schifferstein and Wastiels [15] mentioned effect of “previous life” of a material on metaphorical meanings. Therefore, not only timber but also fabric, as a soft material, could have positive effects on the perception of warmth in interiors.

2. METHOD

2.1 Present Study

The main aim of these two studies is to investigate how paired colors and paired materials affect warmth perception separately under the same experimental conditions and with the same methodology [8, 14]. As colors and materials are rarely viewed in isolation, researchers chose pairs as stimuli in this study [8, 14]. The results of color pairs were presented in the previous report [8]. In the current study, researchers used three material pairs with one fixed color. Each set consisted of two materials and their pairs, and thus every participant saw a set of models with four different stimuli (e.g., Fabric Model, Timber Model, Fabric + Timber Model, and Timber + Fabric Model) (see Table 1, Material Pair-1). Each set was assessed by 32 different participants (16 males and 16 females), for a total of 96 different participants.

The research question: “How can materials be paired in interiors to induce the effective perception of warmth?” was explored. The following result was hypothesized by the researchers: “Different material pairs affect the perception of warmth in interiors.”

2.2 Participants

Ninety-six (96) voluntary people were chosen randomly to participate in the study in Belfast, Northern Ireland, UK. Participants in the material pairs study were not the same participants in the previous color pairs study [8] so that there is neither order effect nor learning/maturation effects. No payment or encouragement were applied. Potential participants who did not have normal color vision were detected by Ishihara Color-Blindness Test and excluded from the experiment. The sample group was between 18 and 68 years of age and included males and females without eye deficiencies (corrective lenses, if necessary, were required to be worn). The average age of the gender balanced sample groups was 32 (see Appendix A, Table A.1).
2.3 Experiment Setting

The same experimental setting, which was used for the previous study, was utilized to exhibit material models [8]. The experiment box (with following dimension: 40 cm height, 50 cm width, and 50 cm depth), a lamp (a Thorn PP118 light bulb with Philips TL-D 90 Graphica 18W 965–59 cm (MASTER) which provided required lighting and viewing conditions), and measurement equipment (NCS 96 Atlas, Konica Minolta Illuminance Meter T-10A, NCS Color Scan 2.0, a temperature gauge, and a digital thermometer with Samsung Galaxy S4 sensors) were used in order to constitute controlled conditions such as controlled light and temperature [8].

Natural light was blocked with curtains and black cardboard to eliminate any effect of changing daylight. The only light source, which ensures 6500 K color temperature, excellent color rendering index with 90 to 100 Ra and approximately 400 lux illuminance level, was the fixture in the experiment box so that it provided homogeneous illuminance level on models and in the box in addition to its excellent color rendering index. The experiment box, which was used to exhibit the models under controlled conditions, was covered with black cardboard from outside and with gray (S-3000N) cardboard inside.

In order to measure physical conditions several measurement equipment were used. The illuminance levels of the models and their environments were measured by a Konica Minolta Illuminance Meter T-10A. NCS 96 Atlas was used to determine colors and NCS Color Scan 2.0 was used to measure the color (Red, with an “S 3070-Y90R” NCS Code) on the models. A temperature gauge and a digital thermometer with Samsung Galaxy S4 sensors were utilized to measure indoor temperature, which was kept at 22°C as stated by Neufert [25], which was controlled with heating equipment when needed.

3. STIMULUS

3.1 Materials

Three typical construction materials which are frequently used in interior architecture were selected: Fabric, Timber, and Plasterboard. Moreover, these materials are preferred because the researchers could modify them without loss of identity on their surfaces with water-based protectors [14, 26]. The researchers chose 100% cotton fabric because of its absorption ability and because it does not include any plastic ingredients, which can cause sparkle on a surface. Fagus-covered laminated veneer boards were selected because of its reaction to paint and sandpaper, which ensured visually and tactually identical surfaces for all timber models and its less obvious grains. The researchers selected the standard plasterboard because of its wide usage with matte paint which does not cause any glare on a surface. Materials and paints were selected in order to ensure similar glossiness level on models' surfaces without any glare on them (see Figure 1).

Wide range of timber and fabric types were investigated, and because timber had more restricted color palette, selection of colors was based on water-based protectors' color palette for timber [14, 26]. Timber and Fabric models were painted with the water-based protector, which can penetrate the surfaces, in order to protect their surface properties. Unlike other dyes, water-based protectors penetrate and protect surface qualities such as texture, grain and structure, and can change surface color properly. Sirca CT5503 paint was used for both Timber models and Fabric models in order to ensure the same color, and Marshall water-based matte indoor wall paint with the same NCS code was used for the Plasterboard models. Color measurements with NCS Color Scan 2.0 after painting process of each model showed that “S 3070-Y90R” NCS code was achieved on all models.

3.2 Models

In order to create pairs, each material was viewed with another material. Any effect of material location was
Participants completed the first part of the questionnaire except the light in the experiment box was turned off. They filled out a consent form. Next, all indoor lighting volunteers received an information form about the experiment. Participants were asked questions about eye and vision deficiencies, and the experiment. Before the first phase, researchers asked the experiment (for details Ref. [8]).

Two pilot studies were conducted before the main experiment. Eight extra orders were selected randomly. Types could be varied for four different models; therefore, different order was fixed, and three different order models were used as pairs: red Fabric and red Timber pair, red Fabric and red Plasterboard pair, and red Timber and red Plasterboard pair.

Researchers used single materials for the material pairs to investigate particularly the relationship between them. Each participant assessed a model set, consisting of four different models, for example, Material Pair Set-1 (see Table I). Each participant assessed the four different models of his or her set one by one. The sets consisted of two single material models and two paired material combination models, which were upside down versions of each other to eliminate any effect of location of material. Each participant assessed four models of their set in a different order to control for the prospective order effect. Twenty four different order types could be varied for four different models; therefore, eight extra orders were selected randomly.

### 3.3 Procedure

Two pilot studies were conducted before the main experiment (for details Ref. [8]). There were two phases of the experiment. Before the first phase, researchers asked participants questions about eye and vision deficiencies, and applied Ishihara’s Color-Blindness Test. The remaining volunteers received an information form about the experiment and, if they still wanted to participate in the experiment, they filled out a consent form. Next, all indoor lighting except the light in the experiment box was turned off. Participants completed the first part of the questionnaire which includes demographic information under controlled experiment conditions, thus provided adaptation time to participants’ eyes. Finally, participants were shown the first model in their set.

The second phase of the experiment included assessing the models under laboratory conditions. Participants answered two open-ended questions, which were previously published in their findings [26] and three direct questions (see Table II) on a 7-point semantic differential scale (1: very cold and 7: very warm; 1: not energetic and 7: energetic; 1: not intimate and 7: intimate), in the same way as the previous study about effects of paired colors on warmth perception [8]. A semantic differential scale was used for these questions: “warm,” “energetic,” and “intimate,” with their opposing adjectives. These three scales were used as descriptors because they are consistently related to the concept throughout the literature [1–3, 13]. In addition, they correspond to Heise’s EPA structure (evaluation, potency, and activity), which is required to probe any concept on semantic differential scales [27]. “Warm” was used for evaluation, whereas “intimate” and “energetic” were utilized for potency and activity, respectively [8]. More scales were not preferred by researchers in order to concentrate the participants on these three fundamental scales of warmth perception [8].

In this study, because the visual assessment is the focus, participants were not allowed to touch the models before or during the experiment. The model represented a corner of an empty room, which was defined as an ordinary interior with no door, furniture, window, or any other interior element [8, 26]. No function was assigned to this interior. Each volunteer, who were individually participating in the experiment, sat on the open front of the experiment box in the same chair. Both paired and single models were split horizontally along the height of a wall halfway in order to represent more common real life indoor wall application and the same area for each material type. To ensure exactly the same visual properties, four fragments were utilized in each model to provide the same conjunction quality for both single material models and paired material models. More details about the methodology were presented in the previous studies by the authors [8, 14, 26].
4. RESULTS
Quantitative questions were investigated by the Wilcoxon matched-pair signed-rank test with IBM’s SPSS Statistics 20 program. All single materials with the other two materials and material pairs were compared. The results of the Wilcoxon test are demonstrated in Tables IV–VII (see Table III for symbols of materials). Both upper and lower combinations of a same material pair (e.g., Fabric upper + Timber lower paired material and Timber upper + Fabric lower paired material combinations) were compared as well (see tables IV–VI). In addition, researchers compared the material pairs with other two material pairs separately (see Table VII). The null hypothesis is the same hypothesis in the previous report [8] that: “two models are the same as each other and there is no difference in warmth perception.”

The Fabric and Timber pair was the first material pair which the researchers analyzed. For the questions regarding “warm” and “energetic,” there was no significant difference between Fabric, Timber, or their pairs (both combinations: Fabric + Timber Combination and Timber + Fabric Combination). For the question regarding “intimate,” the only significant difference between the models was that the Timber + Fabric paired combination (with Timber on top) was found to be more intimate than the Fabric + Timber paired combination (with Fabric on top) (see Table IV), which is the only material location difference in the study.

The Fabric and Plasterboard pair was the second material pair that researchers analyzed. For the question regarding “warm,” Fabric was found to be warmer than Plasterboard and Plasterboard was assessed as the less warm one. There was no significant difference between Fabric and the paired combinations. For the question regarding “energetic,” the only significant difference between the models was that Plasterboard upper Fabric lower combination was found to be more energetic than Plasterboard as a single material. For the question regarding “intimate,” Plasterboard + Fabric paired combination and Fabric + Plasterboard paired combination were more intimate than Plasterboard as a single material. Material location had no effect on warmth perception in the paired combinations (see Table V).

The third material pair, which researchers analyzed, was Timber and Plasterboard material pair. For the question regarding “warm,” Timber was found to be warmer than both single Plasterboard and the Timber + Plasterboard paired combination, while the Plasterboard + Timber paired combination was warmer than Plasterboard as a
Table V. Mean of fabric and plasterboard pair models ($P$-values in parenthesis) and their statistical relations (significance in parenthesis).

<table>
<thead>
<tr>
<th>Mean</th>
<th>Fabric Model</th>
<th>Plasterboard Model</th>
<th>Fabric+Plasterboard Model</th>
<th>Plasterboard+Fabric Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm</td>
<td>5.31 (.000)</td>
<td>4.16 (.616)</td>
<td>5.03 (.000)</td>
<td>5.06 (.000)</td>
</tr>
<tr>
<td>Energetic</td>
<td>3.88 (.683)</td>
<td>3.69 (.315)</td>
<td>4.16 (.596)</td>
<td>4.34 (.215)</td>
</tr>
<tr>
<td>Intimate</td>
<td>4.13 (.699)</td>
<td>3.19 (.007)</td>
<td>4.22 (.507)</td>
<td>4.44 (.133)</td>
</tr>
</tbody>
</table>

The null hypothesis: two models are the same as each other

<table>
<thead>
<tr>
<th>Warm</th>
<th>Fabric vs Plasterboard</th>
<th>Fabric vs Fabric+Plasterboard</th>
<th>Fabric vs Plasterboard+Fabric</th>
<th>Plasterboard vs Fabric+Plasterboard</th>
<th>Plasterboard vs Plasterboard vs Fabric+Plasterboard+Fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm</td>
<td>Rejected (.003)</td>
<td>Null (.392)</td>
<td>Null (.529)</td>
<td>Rejected (.003)</td>
<td>Rejected (.009)</td>
</tr>
<tr>
<td>Energetic</td>
<td>Null (.644)</td>
<td>Null (.386)</td>
<td>Null (.093)</td>
<td>Null (.109)</td>
<td>Rejected (.036)</td>
</tr>
<tr>
<td>Intimate</td>
<td>Null (.052)</td>
<td>Null (.988)</td>
<td>Null (.357)</td>
<td>Rejected (.003)</td>
<td>Rejected (.001)</td>
</tr>
</tbody>
</table>

5. DISCUSSION

Previous studies [1–4] revealed the relationship between material properties and warmth perception; therefore, it could be assumed that different material types have different effects on warmth perception in interiors. In this study, semantic aspect of warmth perception with its three fundamental scales, was investigated on one natural–natural and two natural–artificial material pairs as an interior architecture concept. Fabric as a single material and Timber as a single material were assessed as warmer than Plasterboard as a single material. Their level of warmth became the same, when these three materials were paired (Fabric and Timber material pair, Fabric and Plasterboard material pair, and Timber and Plasterboard material pair). The study reveals that these single materials can have different effects on the perception of warmth in interiors by themselves, but when paired they lose their potency for warmth perception and have similar effects in interiors. The results also show that there is no difference in warmth perception among material location in the combinations (i.e., whether a material is on the top or the bottom of the combination), except Timber and Fabric material pair. It is interesting to note that Timber + Fabric paired material combination is more intimate than Fabric + Timber paired material combination, which are the only natural–natural paired material combinations of the study.

5.1 Warmth

The study results demonstrate that both Fabric and Timber, as single materials, have the same level of warmth; there
is no difference between these materials or among their paired combinations. As single materials, Fabric and Timber were assessed as warmer than Plasterboard separately. Fabric dominates their paired material combinations with Plasterboard (Fabric + Plasterboard paired material combination and Plasterboard + Fabric paired material combination) whereas Timber does not. Fabric and its two paired material combinations found to be warmer than Plasterboard (see Table V). On the other hand, Timber was assessed as warmer than the Timber + Plasterboard paired material combination but equals for warmth in the Plasterboard + Timber paired material combination (see Table VI). Plasterboard + Timber

Table VI. Mean of timber and plasterboard pair models (P-values in parenthesis) and their statistical relations (significance in parenthesis).

<table>
<thead>
<tr>
<th>Mean</th>
<th>Timber Model</th>
<th>Plasterboard Model</th>
<th>Timber+Plasterboard Model</th>
<th>Plasterboard+Timber Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm</td>
<td>5.81 (.000)</td>
<td>4.47 (.092)</td>
<td>4.97 (.000)</td>
<td>5.34 (.000)</td>
</tr>
<tr>
<td>Energetic</td>
<td>4.59 (.063)</td>
<td>3.81 (.482)</td>
<td>4.13 (.666)</td>
<td>4.56 (.016)</td>
</tr>
<tr>
<td>Intimate</td>
<td>5.28 (.000)</td>
<td>3.88 (.730)</td>
<td>4.56 (.045)</td>
<td>4.88 (.002)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The null hypothesis: two models are the same as each other</th>
<th>Timber vs Plasterboard</th>
<th>Timber vs Timber+Plasterboard</th>
<th>Plasterboard vs Timber+Plasterboard</th>
<th>Plasterboard vs Plasterboard+Timber</th>
<th>Timber+Plasterboard vs Plasterboard+Timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm</td>
<td>Rejected (.000)</td>
<td>Null (.098)</td>
<td>Null (.099)</td>
<td>Rejected (.014)</td>
<td>Null (.321)</td>
</tr>
<tr>
<td>Energetic</td>
<td>Null (.085)</td>
<td>Null (.108)</td>
<td>Null (.815)</td>
<td>Rejected (.023)</td>
<td>Null (.187)</td>
</tr>
<tr>
<td>Intimate</td>
<td>Rejected (.003)</td>
<td>Rejected (.041)</td>
<td>Null (.311)</td>
<td>Rejected (.025)</td>
<td>Null (.310)</td>
</tr>
</tbody>
</table>

Table VII. Mean of material pairs (P-values in parenthesis) and their statistical relations (significance in parenthesis).

<table>
<thead>
<tr>
<th>Mean</th>
<th>Fabric+Timber Pair Model</th>
<th>Fabric+Plasterboard Pair Model</th>
<th>Timber+Plasterboard Pair Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm</td>
<td>5.28 (.000)</td>
<td>5.04 (.000)</td>
<td>5.15 (.000)</td>
</tr>
<tr>
<td>Energetic</td>
<td>4.42 (.031)</td>
<td>4.25 (.211)</td>
<td>4.34 (.062)</td>
</tr>
<tr>
<td>Intimate</td>
<td>4.65 (.005)</td>
<td>4.32 (.132)</td>
<td>4.71 (.000)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The null hypothesis: two models are the same as each other</th>
<th>Fabric+Timber versus Fabric +Plasterboard</th>
<th>Fabric+Timber versus Timber+Plasterboard</th>
<th>Timber+Plasterboard versus Fabric+Plasterboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm</td>
<td>Null (.266)</td>
<td>Null (.432)</td>
<td>Null (.557)</td>
</tr>
<tr>
<td>Energetic</td>
<td>Null (.353)</td>
<td>Null (.673)</td>
<td>Null (.656)</td>
</tr>
<tr>
<td>Intimate</td>
<td>Null (.328)</td>
<td>Null (.926)</td>
<td>Null (.152)</td>
</tr>
</tbody>
</table>
paired material combination was assessed as warmer than
the single Plasterboard. However, single Plasterboard equals
to the Timber + Plasterboard paired material combination.
The results could be interpreted that Timber may not be able
to dominate material pairs as much as Fabric does, although,
both have similar effects as natural materials.

5.2 Energy
The results reveal that all single materials were also perceived
the same in terms of energy. As a single material, Plasterboard
was assessed as less energetic than the Plasterboard +
Fabric paired material combination; however, there was
no difference between both other models in terms of
energy. Similarly, Plasterboard as a single material was
perceived as less energetic than the Plasterboard + Timber
paired material combination, and there was no difference
between the other models. According to these results, in
interiors, there is no difference between Fabric, Timber, and
Plasterboard in terms of energy. It might be interpreted that
there is a tendency with higher energy level of Plasterboard
upper paired material combinations, which are paired with
two natural materials separately (Fabric or Timber).

5.3 Intimacy
As a single material there is no difference between Fabric
and Timber in terms of intimacy. However, when paired as
Timber + Fabric paired material combination with Timber
on top, they are perceived as more intimate than the reverse
combination. As single materials, Fabric and Plasterboard
have the same intimacy level, whereas Plasterboard as a single
material appears to be less intimate than both their paired
material combinations. Participants assessed Timber as more
intimate than Plasterboard. Nonetheless when they were
paired, Timber + Plasterboard paired material combination
was perceived less intimate than Timber single material,
and Plasterboard + Timber paired material combination
was assessed as more intimate than Plasterboard alone. As
a less intimate material in the study, there is a tendency with
intimacy level of Plasterboard to be increased by pairing it
with these natural materials.

5.4 Overall Discussion
In this study, warmth perception was investigated through
three semantic scales that constitute the meaning aspect of
the concept. Although, there are slight differences between
these three semantic scales, their results proved that Fabric
and Timber have the same level of perceived warmth that
is higher than Plasterboard, and their three pairs have
the same effect in interiors. These results show that single
materials might affect the perceived warmth in interiors in
similar or different levels. However, their natural–natural
and natural–artificial material pairs may have similar effect
on the concept in interiors. Therefore, the semantic aspect of
the concept might be more apparent with single materials.

The current study demonstrates that natural materials
(Fabric and Timber for this study) are perceived as warmer
than the artificial material (Plasterboard). According to the
previous study, materials that have previously been part of
a living creature are associated with warmth [15]. Similar to
previous studies [15, 19], the results also support that there
is a strong positive correlation between natural materials
and warmth perception in interiors: both cotton fabric and
timber have a “previous life”; therefore, they are related to
“being alive” and thus they might be perceived as warmer.
Knowing that these two materials have rooted from living
organisms might positively affect their perceived warmth in
interiors. As previous studies suggested [15, 19], these results
show that natural materials may be related to figuratively
warm concepts.

Considering the results in general, paired materials
might lose their potency for warmth in interiors. Apparently,
in this study, when natural materials (Fabric or Timber)
are paired with the artificial one (Plasterboard), the paired
materials could be perceived as warmer than the artificial one
on its own. In this study, only one natural–natural and two
natural–artificial material pairs were investigated, there was
not any artificial–artificial material pair. Therefore, it can be
interpreted that natural materials, with a previous life, might
increase warmth level of Plasterboard. However, the pair
of these two natural materials (Fabric and Timber material
pair) cannot have higher degree of warmth than their single
materials on interior walls. It could be suggested that, in
order to provide higher perceived warmth in interiors,
Plasterboard, which has less obvious texture might be used
with natural materials which are less firm and have less
smooth surfaces (instead of single Plasterboard).

Another interesting finding is that the pair of Fabric
and Timber is not warmer than either single Fabric or
single Timber and this phenomenon is consistent for all
three scales. Pairing these two natural materials might cause
overstimulation which was mentioned as a negative feature
of an interior by the previous study [28].

Moreover, the study’s findings revealed that there is no
effect of material location in paired materials, except Fabric
and Timber material pair for intimate scale. The finding
is fruitful because the previous study proved that there is
no effect of color location on warmth perception [8]. In
addition, the other two material pairs, and the warm and
energetic scales of Fabric and Timber material pair, do not
have statistically significant difference in the same context
(see tables IV–VI).

6. CONCLUSION
In this study, the experimental setting was utilized to
investigate the relationship between warmth perception
and material pairs with their single materials, which
frequently appear in interiors. Three fundamental scales
(warm, energetic, and intimate), which constitute the
semantic aspect of warmth perception, were used to probe
the concept in interiors. According to results, the hypothesis
is rejected for these three material pairs in all three
semantic scales; however, study findings could be useful for
different design disciplines and future studies. The results
reveal that both Timber and Fabric, as single materials,
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REFERENCES


APPENDIX A. AVERAGE AGE OF THE SAMPLE GROUP

<table>
<thead>
<tr>
<th>Material pair name</th>
<th>Fabric and timber</th>
<th>Fabric and plasterboard</th>
<th>Timber and plasterboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average age</td>
<td>34</td>
<td>32</td>
<td>30</td>
</tr>
</tbody>
</table>