*Supplementary Data:*

Designing With Biobased Composites: Understanding Material Perception Through Semiotic Attributes

**Table S 1**

Uncertainty In Perception for Materials and Attribute Pairs-Percentage of Respondents Who Rated Can’t Say.

|  |  |  |  |
| --- | --- | --- | --- |
| **Material Sample** | **Perceptual Uncertainty****(Can’t Say %)** | **Attribute Pair** | **Perceptual Uncertainty****(Can’t Say %)** |
| Cellulose + Wood | 26.37% | Hot - Cold | 42.48% |
| NW Sisal | 24.96% | Valuable - Worthless | 32.26% |
| Poplar | 24.78% | Aged - New | 31.30% |
| Cordenka | 24.42% | Strong - Weak | 25.74% |
| Leather | 24.34% | Beautiful - Ugly | 21.08% |
| TW Cotton | 22.39% | Interesting - Boring | 16.89% |
| Walnut | 21.50% | Complex - Simple | 16.65% |
| NW Coir | 21.15% | Unusual - Ordinary | 15.85% |
| TW Flax 1 | 20.62% | Natural - Artificial | 13.11% |
| TW Flax 2 | 19.91% | Rough - Smooth | 11.50% |
| UD Flax | 19.12% |  |

**Table S 2**

Fraction of Positive Responses(Looks Like & Definitely) Against Each attribute

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Aged** | **Complex** | **Interesting** | **Natural** | **Unusual** | **Beautiful** | **Valuable** | **Strong** | **Rough** | **Hot** | **New** | **Simple** | **Boring** | **Artificial** | **Ordinary** | **Ugly** | **Worthless** | **Weak** | **Smooth** | **Cold** |
| **Cellulose + Wood** | 47% | 79% | 81% | 61% | 80% | 58% | 40% | 47% | 41% | 38% | 11% | 7% | 8% | 15% | 7% | 20% | 18% | 21% | 36% | 22% |
| **Cordenka** | 47% | 65% | 75% | 56% | 68% | 43% | 39% | 28% | 38% | 21% | 20% | 18% | 14% | 23% | 18% | 30% | 25% | 40% | 47% | 42% |
| **Leather** | 51% | 60% | 74% | 62% | 58% | 66% | 55% | 54% | 47% | 42% | 14% | 24% | 8% | 14% | 25% | 19% | 14% | 19% | 38% | 13% |
| **NW Coir** | 48% | 69% | 69% | 91% | 66% | 35% | 24% | 31% | 90% | 32% | 18% | 17% | 16% | 5% | 19% | 43% | 43% | 47% | 5% | 21% |
| **NW Sisal** | 41% | 66% | 66% | 78% | 68% | 24% | 25% | 29% | 79% | 38% | 21% | 18% | 15% | 10% | 17% | 51% | 42% | 35% | 12% | 18% |
| **Poplar** | 8% | 24% | 49% | 58% | 17% | 65% | 40% | 53% | 18% | 27% | 66% | 61% | 26% | 26% | 62% | 13% | 27% | 19% | 65% | 31% |
| **TW Cotton** | 64% | 34% | 38% | 65% | 26% | 18% | 31% | 50% | 71% | 18% | 10% | 48% | 39% | 25% | 59% | 56% | 46% | 25% | 20% | 35% |
| **TW Flax 1** | 58% | 50% | 53% | 61% | 28% | 32% | 34% | 66% | 71% | 22% | 14% | 33% | 30% | 27% | 58% | 50% | 36% | 17% | 24% | 33% |
| **TW Flax 2** | 35% | 44% | 54% | 69% | 17% | 47% | 43% | 63% | 74% | 27% | 35% | 42% | 27% | 26% | 67% | 33% | 29% | 20% | 17% | 34% |
| **UD Flax** | 70% | 58% | 75% | 90% | 60% | 41% | 31% | 48% | 86% | 37% | 10% | 26% | 11% | 5% | 24% | 42% | 35% | 31% | 9% | 21% |
| **Walnut** | 28% | 35% | 66% | 73% | 29% | 74% | 58% | 61% | 34% | 43% | 40% | 43% | 21% | 18% | 53% | 12% | 12% | 15% | 54% | 20% |

**Table S 3**

Spearman's Rank Correlation Coefficients for Various Attribute Pairs (Unweighted)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | **Aged** | **Complex** | **Interesting** | **Natural** | **Unusual** | **Beautiful** | **Valuable** | **Strong** | **Rough** | **Hot** | **New** | **Simple** | **Boring** | **Artificial** | **Ordinary** | **Ugly** | **Worthless** | **Weak** | **Smooth** | **Cold** |
| **Aged** | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Complex** | 0.19 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Interesting** | 0.16 | **.747\*\*** | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Natural** | 0.20 | 0.18 | 0.05 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Unusual** | 0.16 | **.904\*\*** | **.799\*\*** | 0.10 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Beautiful** | -0.54 | -0.14 | 0.33 | -0.26 | -0.10 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Valuable** | -0.47 | -0.35 | 0.08 | -0.41 | -0.32 | **.872\*\*** | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Strong** | -0.06 | **-.627\*** | -0.48 | -0.09 | **-.767\*\*** | 0.31 | 0.57 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |
| **Rough** | 0.53 | 0.39 | 0.05 | **.765\*\*** | 0.17 | **-.647\*** | **-.707\*** | -0.19 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |
| **Hot** | -0.26 | 0.32 | 0.46 | 0.40 | 0.35 | 0.58 | 0.38 | 0.04 | -0.05 | 1.00 |   |   |   |   |   |   |   |   |   |   |
| **New** | **-.924\*\*** | -0.29 | -0.29 | -0.12 | -0.30 | 0.45 | 0.39 | 0.15 | -0.42 | 0.17 | 1.00 |   |   |   |   |   |   |   |   |   |
| **Simple** | -0.19 | **-.998\*\*** | **-.769\*\*** | -0.15 | **-.906\*\*** | 0.12 | 0.33 | **.633\*** | -0.36 | -0.29 | 0.30 | 1.00 |   |   |   |   |   |   |   |   |
| **Boring** | -0.09 | **-.702\*** | **-.904\*\*** | -0.02 | **-.755\*\*** | -0.39 | -0.12 | 0.49 | 0.01 | **-.606\*** | 0.22 | **.708\*** | 1.00 |   |   |   |   |   |   |   |
| **Artificial** | -0.27 | **-.635\*** | **-.629\*** | **-.668\*** | **-.670\*** | 0.04 | 0.39 | 0.60 | -0.51 | -0.57 | 0.30 | **.618\*** | **.691\*** | 1.00 |   |   |   |   |   |   |
| **Ordinary** | -0.15 | **-.891\*\*** | **-.765\*\*** | -0.11 | **-.995\*\*** | 0.11 | 0.34 | **.773\*\*** | -0.17 | -0.37 | 0.28 | **.888\*\*** | **.752\*\*** | **.685\*** | 1.00 |   |   |   |   |   |
| **Ugly** | 0.58 | 0.15 | -0.33 | 0.34 | 0.07 | **-.982\*\*** | **-.822\*\*** | -0.22 | **.729\*** | -0.50 | -0.49 | -0.13 | 0.38 | -0.07 | -0.07 | 1.00 |   |   |   |   |
| **Worthless** | 0.44 | 0.00 | -0.48 | 0.40 | -0.11 | **-.927\*\*** | **-.877\*\*** | -0.21 | **.706\*** | -0.56 | -0.33 | 0.02 | 0.51 | -0.05 | 0.09 | **.918\*\*** | 1.00 |   |   |   |
| **Weak** | 0.27 | 0.58 | 0.34 | 0.31 | 0.57 | -0.55 | **-.753\*\*** | **-.870\*\*** | 0.56 | -0.27 | -0.27 | -0.59 | -0.27 | -0.57 | -0.56 | 0.51 | 0.52 | 1.00 |   |   |
| **Smooth** | -0.51 | -0.41 | -0.07 | **-.761\*\*** | -0.21 | **.673\*** | **.735\*\*** | 0.25 | **-.989\*\*** | 0.07 | 0.44 | 0.38 | -0.01 | 0.51 | 0.21 | **-.745\*\*** | **-.727\*** | **-.606\*** | 1.00 |   |
| **Cold** | 0.06 | -0.30 | -0.29 | -0.53 | -0.29 | -0.31 | -0.08 | 0.01 | -0.18 | **-.902\*\*** | -0.07 | 0.26 | 0.52 | **.664\*** | 0.34 | 0.24 | 0.26 | 0.14 | 0.12 | 1.00 |
| \*\* Correlation is significant at the 0.01 level (2-tailed). \* Correlation is significant at the 0.05 level (2-tailed).  |

*Note:* ∎ *Significant (Inverse) correlations*, ∎ *Significant (Negative) correlations and* ∎ *Significant (Positive) correlations.*

**Table S 4**

Spearman's Rank Correlation Coefficients for Various Attribute Pairs (Weighted)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | Aged | Complex | Interesting | Natural | Unusual | Beautiful | Valuable | Strong | Rough | Hot | New | Simple | Boring | Artificial | Ordinary | Ugly | Worthless | Weak | Smooth | Cold |
| Aged | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Complex | 0.21 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Interesting | 0.24 | .717\* | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Natural | -0.03 | 0.24 | 0.00 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Unusual | 0.20 | .943\*\* | .797\*\* | 0.21 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Beautiful | -0.51 | -0.12 | 0.43 | -0.29 | 0.02 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Valuable | -0.36 | -0.32 | 0.20 | -0.51 | -0.26 | .854\*\* | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Strong | 0.00 | -.648\* | -0.33 | -0.38 | -.656\* | 0.28 | .638\* | 1.00 |   |   |   |   |   |   |   |   |   |   |   |   |
| Rough | 0.53 | 0.43 | 0.02 | 0.59 | 0.23 | -.682\* | -.616\* | -0.25 | 1.00 |   |   |   |   |   |   |   |   |   |   |   |
| Hot | -0.19 | 0.35 | .653\* | 0.17 | 0.41 | 0.60 | 0.41 | -0.03 | -0.08 | 1.00 |   |   |   |   |   |   |   |   |   |   |
| New | -.936\*\* | -0.32 | -0.32 | -0.09 | -0.34 | 0.50 | 0.41 | 0.14 | -0.48 | 0.17 | 1.00 |   |   |   |   |   |   |   |   |   |
| Simple | -0.20 | -.986\*\* | -.781\*\* | -0.20 | -.980\*\* | 0.03 | 0.27 | .630\* | -0.32 | -0.39 | 0.32 | 1.00 |   |   |   |   |   |   |   |   |
| Boring | -0.09 | -.692\* | -.913\*\* | -0.07 | -.729\* | -0.39 | -0.13 | 0.49 | -0.05 | -.753\*\* | 0.17 | .726\* | 1.00 |   |   |   |   |   |   |   |
| Artificial | -0.36 | -.711\* | -.674\* | -.638\* | -.736\*\* | 0.10 | 0.37 | 0.57 | -0.56 | -0.55 | 0.44 | .711\* | .715\* | 1.00 |   |   |   |   |   |   |
| Ordinary | -0.20 | -.881\*\* | -.772\*\* | -0.15 | -.952\*\* | 0.03 | 0.34 | .731\* | -0.14 | -0.33 | 0.35 | .932\*\* | .740\*\* | .683\* | 1.00 |   |   |   |   |   |
| Ugly | 0.60 | 0.19 | -0.32 | 0.20 | 0.08 | -.975\*\* | -.840\*\* | -0.32 | .679\* | -0.55 | -0.55 | -0.12 | 0.30 | -0.17 | -0.12 | 1.00 |   |   |   |   |
| Worthless | 0.42 | 0.00 | -0.51 | 0.36 | -0.12 | -.918\*\* | -.872\*\* | -0.30 | .627\* | -0.59 | -0.39 | 0.09 | 0.45 | -0.06 | 0.10 | .870\*\* | 1.00 |   |   |   |
| Weak | 0.17 | 0.50 | 0.08 | 0.48 | 0.45 | -0.50 | -.765\*\* | -.874\*\* | 0.50 | -0.29 | -0.24 | -0.44 | -0.17 | -0.48 | -0.47 | 0.52 | 0.56 | 1.00 |   |   |
| Smooth | -0.52 | -0.44 | 0.00 | -.665\* | -0.25 | .718\* | .671\* | 0.33 | -.982\*\* | 0.11 | 0.53 | 0.33 | 0.04 | 0.59 | 0.17 | -.697\* | -.664\* | -0.56 | 1.00 |   |
| Cold | 0.04 | -0.41 | -0.51 | -0.17 | -0.41 | -0.30 | -0.17 | 0.02 | -0.13 | -.911\*\* | -0.06 | 0.42 | .624\* | 0.55 | 0.33 | 0.24 | 0.31 | 0.28 | 0.07 | 1.00 |
| \*\* Correlation is significant at the 0.01 level (2-tailed). \* Correlation is significant at the 0.05 level (2-tailed).  |

*Note:* ∎ *Significant (Inverse) correlations*, ∎ *Significant (Negative) correlations and* ∎ *Significant (Positive) correlations.*

**Table S 5**

Attributes And Respective Number of Statistically Significant Correlations Along with Percentage of Can’t Say Ratings.

|  |  |
| --- | --- |
| **Attributes** *(with number of significant correlations)* | **Can’t Say** *[average %, for each pair]* |
| Rough (5) | Smooth (6) | 11.50% |
| Natural (2) | Artificial (7) | 13.11% |
| Unusual (6) | Ordinary (6) | 15.85% |
| Complex (6) | Simple (6) | 16.65% |
| Interesting (5) | Boring (6) | 16.89% |
| Beautiful (4) | Ugly (4) | 21.08% |
| Strong (4) | Weak (2) | 25.74% |
| Aged (0) | New (0) | 31.30% |
| Valuable (5) | Worthless (4) | 32.26% |
| Hot (1) | Cold (1) | 42.48% |



**Figure S 1** Simplified Attribute Relations Developed by Combining Bipolar Adjectives



**Figure S 2** Clustering of materials using k-means algorithm

**Table S 6**

Correlation Between Attribute Ratings Amongst Female and Male Groups

|  |  |  |  |
| --- | --- | --- | --- |
| **Attribute** | **Female- Male Correlation** | **Attribute** | **Female- Male Correlation** |
| Correlation Coefficient | Sig. (2-tailed) | Correlation Coefficient | Sig. (2-tailed) |
| Aged | .840\*\* | 0.001 | New | .772\*\* | 0.005 |
| Complex | .845\*\* | 0.001 | Simple | .888\*\* | 0.000 |
| Interesting | .775\*\* | 0.005 | Boring | .758\*\* | 0.007 |
| Natural | .869\*\* | 0.001 | Artificial | .931\*\* | 0.000 |
| Unusual | .908\*\* | 0.000 | Ordinary | .818\*\* | 0.002 |
| Beautiful | .964\*\* | 0.000 | Ugly | .973\*\* | 0.000 |
| Valuable | .858\*\* | 0.001 | Worthless | .845\*\* | 0.001 |
| Strong | .889\*\* | 0.000 | Weak | .800\*\* | 0.003 |
| Rough | .888\*\* | 0.000 | Smooth | .890\*\* | 0.000 |
| Hot | .867\*\* | 0.001 | Cold | .748\*\* | 0.008 |
| *\*\*. Correlations are significant at the 0.01 level (2-tailed).* |

**Table S 7**

Correlation Between Attribute Ratings Amongst Young (<=27) And Old (>27) Age Groups

|  |  |  |  |
| --- | --- | --- | --- |
| **Attribute** | **Young - Old Correlation** | Attribute | **Young - Old Correlation** |
| Correlation Coefficient | Sig. (2-tailed) | Correlation Coefficient | Sig. (2-tailed) |
| Aged | .897\*\* | 0.000 | New | .858\*\* | 0.001 |
| Complex | .722\* | 0.012 | Simple | .895\*\* | 0.000 |
| Interesting | .633\* | 0.037 | Boring | .770\*\* | 0.006 |
| Natural | .644\* | 0.033 | Artificial | **0.602** | **0.050** |
| Unusual | .827\*\* | 0.002 | Ordinary | .795\*\* | 0.003 |
| Beautiful | .906\*\* | 0.000 | Ugly | .805\*\* | 0.003 |
| Valuable | .753\*\* | 0.007 | Worthless | .697\* | 0.017 |
| Strong | .802\*\* | 0.003 | Weak | .737\*\* | 0.010 |
| Rough | .920\*\* | 0.000 | Smooth | .973\*\* | 0.000 |
| Hot | .762\*\* | 0.006 | Cold | **0.599** | **0.052** |
| *\*\*. Correlation is significant at the 0.01 level (2-tailed).* |
| *\*. Correlation is significant at the 0.05 level (2-tailed).* |

**Table S 8**

Correlation Between Attribute Ratings Amongst ESBBC And General Participant Groups

|  |  |  |  |
| --- | --- | --- | --- |
| **Attribute** | **ESBBC-General Correlation** | Attribute | **ESBBC-General Correlation** |
| Correlation Coefficient | Sig. (2-tailed) | Correlation Coefficient | Sig. (2-tailed) |
| Aged | .918\*\* | 0.000 | New | .920\*\* | 0.000 |
| Complex | .947\*\* | 0.000 | Simple | .890\*\* | 0.000 |
| Interesting | .713\* | 0.014 | Boring | .917\*\* | 0.000 |
| Natural | .726\* | 0.011 | Artificial | .628\* | 0.038 |
| Unusual | .895\*\* | 0.000 | Ordinary | .934\*\* | 0.000 |
| Beautiful | .740\*\* | 0.009 | Ugly | .784\*\* | 0.004 |
| Valuable | **0.469** | **0.146** | Worthless | **0.543** | **0.085** |
| Strong | .640\* | 0.034 | Weak | .606\* | 0.048 |
| Rough | .936\*\* | 0.000 | Smooth | .964\*\* | 0.000 |
| Hot | .609\* | 0.047 | Cold | .716\* | 0.013 |
| *\*\*. Correlation is significant at the 0.01 level (2-tailed).* |
| *\*. Correlation is significant at the 0.05 level (2-tailed).* |