Smooth as Glass and Hard as Stone? On the Conceptual Structure of the Aesthetics of Materials

Barbara E. Marschallek *[1], Valentin Wagner **[1,2], and Thomas Jacobsen***[1]

[1] Experimental Psychology Unit, Helmut Schmidt University / University of the Federal Armed Forces Hamburg

[2] Department of Language and Literature, Max Planck Institute for Empirical Aesthetics, Frankfurt

* Please address correspondence to Barbara E. Marschallek (Experimental Psychology Unit, Helmut Schmidt University/University of the Federal Armed Forces Hamburg, Postbox 700822, 22008 Hamburg, Germany; marschab@hsu-hh.de).

** Experimental Psychology Unit, Helmut Schmidt University/University of the Federal Armed Forces Hamburg, Postbox 700822, 22008 Hamburg, Germany; wagnerv@hsu-hh.de

*** Experimental Psychology Unit, Helmut Schmidt University/University of the Federal Armed Forces Hamburg, Postbox 700822, 22008 Hamburg, Germany; jacobsen@hsu-hh.de

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Abstract

Following Fechner's (1876) "aesthetics from below," (1876) this study examines the conceptual structure of the aesthetics of various materials (*Werkstoffe*)—for instance, leather, metal, and wood. Adopting a technique used by Jacobsen et al. (2004), we asked 1,956 students to write down adjectives that could be used to describe the aesthetics of materials within a given time limit. A second subsample of a broader cross-section of the population (n = 496) replicated the findings obtained with the first subsample. A joint analysis of both subsamples identified the term "smooth" as by far the most relevant term, followed by the other core terms "hard," "rough," "soft," and "glossy". Furthermore, sensorial qualities (e.g., "warm" and "see-through") constituted the main elements of the aesthetics of materials, and the great majority of these were haptic qualities (e.g., "cold" and "heavy"). The terms offered were mostly descriptive and of rather neutral valence, according to an additional valence rating study that we conducted with 94 participants. Comparisons between the terms offered for different materials revealed commonalities as well as material specificity of the conceptual structure of the aesthetics. In addition, the word "beautiful", although by no means representing one of the most relevant terms in this study, still proved its preeminence in aesthetics in general. The results of this study contribute to the corpus of existing studies of the conceptual structure of aesthetics.

Keywords: empirical aesthetics, material, free listing, conceptual structure, haptics

Introduction

Theoretical Background

Materials and different material substances,[1] understood as the physical substances that constitute many kinds of human works—for example, buildings, furniture, or vehicles—play an essential role in everyday life. Every human being is confronted with them, consciously or unconsciously, willingly or unwillingly. Through our senses, we continually interact with all kinds of material substances, whether this involves the squeaking sound of old wood boards when we walk on them, the smell of a leather sofa, or the gloss of the metal rims on a car. Through interactions with all manner of products, we actively and passively experience the sensorial characteristics of materials, the so-called *tangible properties* (Karana et al., 2009), such as thickness or hardness. In industrial design, material substances receive both experimental and theoretical attention, an acknowledgment of their prominent role in determining how pleasing, or displeasing, a product will be for the user (Jordan, 2000). Therefore, it is important to differentiate between what material actually is, that is, in physical terms, what it does to the beholder (Manzini, 1986), and how this experience is described. Ashby and Johnson (2014) have pointed out that people expect not only function but also delight, in the products they purchase. This observation underlines that materials have two roles in product design: to provide technical functionality and to create product personality, or impart a certain character to the product. The latter role arises because materials also have *intangible characteristics* (Karana et al., 2008, 2009), including perceived values, cultural meanings, trend issues, associations, and emotions (Karana et al., 2008). *Materials experience*, a term formalized by Karana et al. (2014), refers to

[1] It is important to note that the two terms in the German language are unambiguous. We use "material substances" throughout this article as a generic term for the German word *Materialien*. In contrast, we use the English term "materials" for the German word *Werkstoffe*.

the experience that people have with and through materials. As the Material Experience Lab (n.d.) summarizes, “Material is a Medium. It communicates ideas, beliefs, approaches; compels us to think, feel and act in certain ways; enables and enhances functionality and utility.” Thus, through their interactions, users ascribe particular meanings to material substances (e.g., Ashby & Johnson, 2014; Karana et al., 2008, 2009; Zuo et al., 2001, 2004).

Due to their tangible and intangible characteristics, material substances may satisfy hedonic needs. Through appealing to the senses and evoking meanings, material substances have an aesthetic dimension. Thus, as beholders interacting with material substances, we may have an *aesthetic experience*, as Baumgarten (1750–1758/2007) called it. Aesthetic processing can be defined as a “sensation-based evaluation of an entity with respect to the . . . conceptual system, primarily the beauty dimension” (Jacobsen, 2006, p. 158). This sensation-based evaluation of material substances can be evoked through a variety of sensorial attributes: Tactile, visual, acoustic, olfactory, and/or gustatory features might please us and our senses, as materials “record […] creations of the artists” (Kászonyi, 1982, p. 190). But what does the conceptual structure underlying the aesthetics of materials look like? Considering the importance of the materials’ sensorial attributes and the relevance of the conceptual system in aesthetic processing, the importance of analyzing their conceptual structure becomes apparent (Istók et al., 2009). In the present study this refers to determining, classifying, and interpreting qualities individuals commonly ascribe to specific materials as well as to materials in general. Although, as already noted, a variety of research has been devoted to investigating the aesthetic design aspects of material substances, we lack an analysis of the conceptual structures that underlie the aesthetic experiences of materials. It is a domain of interdisciplinary interest (e.g., Wilkes et al., 2016), including design, engineering, manufacturing, crafts, and psychological perspectives (Marschallek & Jacobsen, 2020). With the present study, we hope to support all these

stakeholders in their work. Designers, for example, combine technical functionality with product personality. The latter is also reflected in the qualities individuals commonly ascribe to them. The knowledge about these might help the experts in their designing process. Further, we suggest that concepts elicited in this study can also be made fruitful by engineers when creating rating scales for their research. Kansei Engineering, for example, defines a "consumer's psychological feeling and image regarding a new product" (Nagamachi, 1995, p. 4) and includes "using all the senses of sight, hearing, feeling, smell, taste as well as her cognition" (Schütte et al., 2004, p. 216). Last but not less important, we aim to provide support for further empirical research on materials experience in psychology—for example, investigating underlying neural mechanisms. The knowledge of qualities individuals commonly ascribe to materials might help researchers in the selection of specific materials and manipulation of relevant tangible properties.

Exploring the Aesthetic Experiences of Materials

The present study investigates the conceptual structure of the aesthetics of various materials following Fechner's (1876) "aesthetics from below." When communicating their perceptions as well as their evaluations of materials, individuals project their experience onto the realm of verbally available concepts and choose those that are most representative. Language-based methods of determining and analyzing these verbal associations provide insight into the mental representations of conceptual structures and organizations of the semantic field of people who share a linguistic background (e.g., Fehr & Russell, 1984; Kuehnast et al., 2014; Nelson et al., 2004; Santos et al., 2011). The aim of the present study was to elucidate the conceptual structure of the aesthetics of material in general (*Werkstoffe*) as well as of relevant subcategories (Marschallek & Jacobsen, 2020), using a verbal association method, a free listing task. That is, a further objective was to determine a potential material category specificity. Therefore, in addition to materials in general, we selected nine subcategories for the purpose of this research: ceramics,

glass, stone, leather, metal, paper, plastic, textiles and wood.[2] We anticipated that (a) these 10 categories would be meaningful even for laypersons and that (b) more specific and detailed subcategories designating special materials (such as different kinds of wood-based panels) might be too specific for the broader public examined in this study.

To this end, we drew on a method that was introduced by Jacobsen et al. (2004), who investigated the conceptual structure of the aesthetics of objects. This method was subsequently used by Istók et al. (2009) for the aesthetics of music, by Augustin et al. (2012) for the aesthetics of several visual domains, by Knoop et al. (2016) for the aesthetics of literature in general and different genres, and by Jacobsen and Beudt (2017) for the aesthetics of voices.

For our data acquisition, we initially recruited students from different academic disciplines (Subsample 1). In order to obtain valid and reliable findings, we replicated the study with a second subsample, for which we approached and recruited individuals in the waiting rooms of citizen centers and vehicle registration authorities (Subsample 2). Our analyses revealed a successful replication of the results obtained from Subsample 1. Therefore, in what follows, we report the results for the entire sample. For additional information on the two subsamples, as well as the results comparing Subsample 1 and 2, see online Supplemental Materials S1 and S2.

Method

Participants

A final sample of 2,452 individuals (1,252 women, 1,157 men, 21 diverse, and 22 who did not report their sex) participated in the study; 1,853 of these individuals were recruited in Hamburg and 599 in Erfurt.[3] Of the final sample, 1,956 individuals constituted Subsample 1 and 496 participants Subsample 2. The participants' mean reported age was 25.3 years (*SD* = 11.0,

[2] This study was conducted in the German language. For the original terms, see the instructions in Appendix.
[3] The study was conducted in two German cities in order to obtain a higher external validity, i.e., to avoid possible dialectal staining. These cities were selected for pragmatic reasons, i.e., personal contacts.

ranging from 16 years to 92 years; 52 participants did not report their age). Most of the participants (n = 2,156) reported German as their only native language, while an additional 114 participants reported German and another language as their mother tongues. Because the majority of the participants were currently students (n = 1,961) and did not consider themselves experts in the field of materials (n = 2,271), we regarded the sample as having a generally high level of education but no specific expertise in materials. Seventy-two additional participants from the total sample were excluded from further analysis due to nonserious respondent behavior (n = 62) or an age younger than 16 years (n = 10). Lists that we regarded as being nonserious respondent behavior were either empty (i.e., no terms listed), contained (sexually) abusive adjectives, contained only terms belonging to other lexical categories (i.e., nouns, verbs), or sentences. The study was performed in accordance with the declaration of Helsinki and had research ethics committee approval from the university where the research was conducted.

Materials and Procedure

The study was conducted as a paper-and-pencil survey, using a between-participants design in order to avoid priming specific associations for categories by the associations of the previous categories. Participants were randomly assigned to the 10 categories of materials. The number of participants per category varied between 208 and 309 participants. For Subsample 1, the study was conducted at the beginning or end of a lecture. Sealed questionnaires were handed to the participants with a short greeting on top, assuring that all participants began the survey only after receiving the instructions. For Subsample 2, participants completed the study in individually administered surveys. These participants received clipboards and pens to enhance the writing quality. In both subsamples, the instructions were presented aurally by the experimenter as well as visually, either by a projection on a screen (Subsample 1) or with laminated prints (Subsample 2), and these remained visible throughout the task to ensure that

participants could reread them. The instructions were adopted from Jacobsen et al. (2004), as follows: “Please write down terms that could be used to describe the aesthetics of … as a material. Please use adjectives only. You now have 2 minutes.”[4] Depending on the specific category, the instructions included one of the words “ceramics,” “glass,” “leather,” “metal,” “paper,” “plastic,” “stone,” “textiles,” “wood,” or materials (in the last case, the phrase “as material” was omitted from the instructions). Two minutes time-on-task is well established in this line of research, that is, using it increases the comparability with previous studies (Jacobsen et al., 2004; Jacobsen & Beudt, 2017; Knoop et al., 2016). After 2 min, participants were instructed to stop writing and asked to answer questions on the back of the questionnaire regarding demographic data, including gender, age, mother tongue, education, and current occupation, as well as whether they considered themselves experts on materials. No time limit was set for this part of the survey. All participants remained anonymous.

Data Analysis

First, the data were preprocessed for analysis.[5] Spelling mistakes were corrected. Neologisms as well as foreign words could not be ruled out since such terms form part of the conceptual structure. Analyses were conducted regarding four aspects: (a) How many (valid) answers were given overall, on average per participant, and per category? (b) Which words were most prominent across and within each category? Was there a relation to word frequencies in the general language use? What was the emotional valence of the words listed? (c) Did the 10 categories differ regarding the specific aesthetic words that were listed? (d) How did the most frequently produced words relate in an overall semantic map? The results are presented in four corresponding subsections of the “Results” section below.

[4] For the original German instructions, see Appendix. Note that in the original instructions, we used the unambiguous German word *Werkstoffe*, which does not leave room for misunderstanding.
[5] Terms displayed in all figures and tables are translations of the original data (see Table A1).

For the analysis of aspect (b), only terms mentioned by at least 5% of the participants in a particular category were retained for the analysis in order to reduce variability that might be due to idiosyncratic uses. For each individual term in a category, we calculated its frequency relative to the sample size for that category, its mean list rank (the average list position for that term in that category) and the cognitive salience index (CSI; the quotient of the relative frequency and mean list rank; Sutrop, 2001). The CSI ranges between 0 and 1, with higher values representing more salient terms.

To determine whether participants produced fairly common or uncommon terms, we extracted word frequency in general language use from two sources. First, using COSMAS II,[6] the Leibniz-Institut für Deutsche Sprache's (Leibniz Institute for the German Language) online portal for research on text corpora, we determined the relative frequency per million wordforms for each adjective in the written German language. Second, we determined the frequency class for each adjective as provided by the German Duden dictionary website.[7] There are five frequency classes ranging from 1 (low frequency) to 5 (high frequency) that can be obtained for specific parts of speech; thus, the frequency classes we used refer only to adjectives.

To establish the emotional valence of the adjectives, we additionally conducted a valence rating study because the valence ratings available from a published source (Hager & Hasselhorn, 1994) are not only insufficient in number (ratings were available for only 44 of the 101 adjectives listed by our participants, i.e., 43.6%) but might also be outdated. Therefore, we obtained ratings from 94 additional participants (38 women, 54 men, 2 diverse) through an online survey. The participants were students (n = 43) or employees at the university where the research was conducted. The mean age of the sample was 31.3 years (SD = 10.6), with ages ranging from 18 to

[6] https://cosmas2.ids-mannheim.de/cosmas2-web/
[7] https://www.duden.de/hilfe/haeufigkeit

59. In conformity with the ratings in Hager and Hasselhorn (1994), the participants rated the listed adjectives on a 7-point bipolar scale with three anchors: 3 (*negative*), 0 (*neutral*), and 3 (*positive*).

For the analysis of aspects (c) and (d), only terms that were mentioned by at least 10% of the participants in at least one of the categories were used. To compare the individual categories, we calculated the Ružička similarity (Deza & Deza, 2013; Podani et al., 2013; Ružička, 1958; Warrens, 2016) and then fed it into a hierarchical cluster analysis (HCA; see Figure S1) as well as a classical multidimensional scaling (MDS; Gower, 1966; see Figure S2). In order to investigate the general semantic field for the aesthetics of materials beyond the category-specific findings, we computed a dissimilarity matrix using the Jaccard index (Real & Vargas, 1996) based on the co-occurrence of the terms that appeared on all participants' lists. First, this matrix was submitted to a hierarchical cluster analysis (employing Ward's criterion). As an aim was to integrate potential commonalities as well as material specificities of the conceptual structure of the aesthetics of materials in an overall semantic map, the matrix was subsequently fed into a nonmetric MDS procedure.

Results

Sample Statistics

Participants generated 18,308 answers in total, including illegible entries and terms listed twice by the same participant. The answers corresponded to 2,270 different valid words. The number of answers produced per participant ranged between 1 and 25 ($M = 7.47$, $SD = 3.87$). There were statistically significant differences between the number of entries for the different categories, Welch's $F(9, 971.87) = 17.70$, $p < .001$.[8] The mean number of entries for the

[8] We computed a Welch's test for unequal variances since there was no homogeneity of variance (Levene's test, $p < .001$).

categories materials in general (M = 8.71, SD = 4.57), stone (M = 8.98, SD = 3.99), wood (M = 8.42, SD = 4.06), and textiles (M = 8.39, SD = 4.12) were larger than those for the other categories (these comparisons were based on the Games-Howell post hoc test; for details see online Supplemental Materials S3).[9]

Results for the Various Material Categories

Applying a 5% cutoff procedure, 101 terms remained for the following analyses. The results obtained for the terms within each category are depicted in Figure S3.

Overall, "smooth" turned out to be one of the five most frequently listed adjectives (45.1%), followed by "hard," "rough," "soft," and "glossy" (26.7%, 26.4%, 24.5%, and 21.8%, respectively). Being listed by at least 20% of the participants across all categories (Weller et al., 2018), these five concepts will be considered the core terms in the following. Among these terms, only "smooth" and "hard" were mentioned in all categories by at least 5% of the participants, along with "glossy" and "solid". The highest frequency for "smooth" was in the category leather (65.4%), and "smooth" was also the most frequently mentioned adjective for plastic, ceramics, wood, and materials in general and the second most frequently mentioned for glass, metal, paper, and stone. For textiles, "smooth" only ranked sixth highest. "Hard" ranked highest for stone (61.0%), second highest for plastic (24.6%), and third highest for metal (43.3%) and wood (33.7%), whereas "rough" ranked second for wood (36.6%) and textiles (31.2%) and third for leather (42.1%) and stone (44.4%). "Soft" was the most frequently mentioned adjective for textiles (62.4%), and it ranked second for materials (40.1%) and leather (52.4%), third for plastic (22.4%), and fifth for paper (20.7%).

As measured by the CSI, the category materials in general was characterized by a variety of adjectives, including a large number of the core terms, that is, "smooth," "soft," "hard," and

[9] Differences for the 45 comparisons were calculated using an alpha level of .01.

"rough". Additionally, "beautiful" was also one of the first five terms for materials in general. For the category glass, the term "see-through," followed by "smooth," "clear," "glossy," and "fragile," ranked particularly high. For the category ceramics, the terms "smooth," "glossy," "beautiful," and "white" were most salient. "Smooth" was the highest ranked term for leather, followed by "soft," "rough," and "brown". Metals were also characterized as "smooth," "hard," and "cold," but "glossy" was the most salient word for this category. "White" and "smooth" were most important for characterizing paper. In addition to "smooth," "hard," and "soft," the terms "malleable," "cheap," and "colorful" ranked high for plastic. "Smooth," "rough," and "grey" were important terms for stone, but "hard" was the most salient term. For textiles, the term "soft" had the greatest CSI, yet the terms "beautiful," "rough," "fluffy," and "colorful" were also relevant. For the category wood, the terms "brown," "beautiful," and "natural" turned out to be relevant in addition to "smooth," "rough," "hard," and "soft."

"Beautiful," the primary and prototypical term for aesthetics, was mentioned for nine categories by more than 5% of the participants, with an overall relative frequency of 15.4%. It was not mentioned for plastic, and it ranked highest for materials in general and textiles (in the fifth and third positions, respectively, with relative frequencies of 30.2% and 29.4%). Additionally, the term "ugly" was mentioned by more than 5% for (only) these two categories (7.9% and 11.0%, respectively). Another aesthetically evaluative term in addition to these two terms, "elegant," was mentioned by at least 5% of the participants for glass, ceramics, and textiles.

In order to assess an influence of general language use, correlations of word frequency in general language use (COSMAS II; Duden) and production frequency in the present study (Table A1, Column 2) were computed. Correlations turned out to be significant, COSMAS II (Table A1, Column 5): $r_s = .52$, $p < .001$; Duden (Table A1, Column 6): $r_s = .49$, $p < .001$.

To determine the emotional valence of the words listed by the participants, we utilized the ratings given in Hager and Hasselhorn (1994; Table A1, Column 3) and means obtained in our additional valence rating study (Table A1, Column 4). An analysis of both of these sources revealed that most of the adjectives were nonevaluative in nature. That is, the majority of the adjectives (n = 60, 59.4%) were rated in our study as neutral, 33 (32.7%) were rated as positive, and only eight were rated as negative (7.9%; the numbers based on Hager and Hasselhorn were 29, 10, and five, respectively). In the valence rating study we conducted, "beautiful" scored second highest (M = 2.07, SD = 1.00), following "high-quality" *(*M = 2.17, SD = 1.02). "Ugly" scored second lowest (M = −2.22, SD = 1.20), while "polluting" scored lowest (M = −2.45, SD = 0.99).

Comparing the Various Materials

After applying the 10% cutoff procedure, 51 terms remained for the following analyses.

Please insert Figure 1 about here

The Ružička similarity of the 10 categories ranged between .21 and .52, with the least similarity between metal and textiles and the largest between materials in general and wood, followed by a large similarity between materials in general and stone (see Table 1). In general, materials in general proved to be most similar to most of the other categories, and glass the least.

Table 1

Descriptive statistics of the categories

Category	$n_{participants}$	$n_{answers}$	$M_{answers}$ ($SEM_{answers}$)	Number of terms listed by more than 5%	Number of terms listed by more than 10%	1	2	3	4	5	6	7	8	9
1 Materials	252	2194	8.71 (0.29)	30	12									
2 Ceramics	208	1346	6.47 (0.22)	22	9	.46								
3 Glass	309	2007	6.50 (0.20)	25	11	.31	.45							
4 Leather	309	2280	7.38 (0.19)	28	17	.47	.37	.25						
5 Metal	224	1553	6.93 (0.23)	26	10	.45	.42	.29	.34					
6 Paper	213	1404	6.60 (0.25)	20	8	.39	.38	.31	.31	.27				
7 Plastic	232	1460	6.29 (0.23)	23	12	.45	.42	.35	.33	.37	.44			
8 Stone	241	2163	8.98 (0.26)	31	15	.49	.31	.22	.34	.41	.27	.29		
9 Textiles	218	1830	8.39 (0.28)	33	14	.46	.30	.23	.36	.21	.31	.33	.23	
10 Wood	246	2071	8.42 (0.26)	25	14	.52	.35	.24	.47	.35	.33	.36	.36	.37

Note. Columns 7–15 present the Ružička similarities between the categories. *SEM* = standard error of the mean.

The categories materials in general and wood showed great similarity, showing a high occurrence of the core terms “smooth,” “hard,” “rough,” and “soft” (see Figure 1). A noteworthy exception was the variety of visual concepts, such as “bright,” “brown,” “dark,” and “grained,” that stood out for the category wood. For the category materials in general no other terms had specific salience, although a variety of terms were mentioned by at least 5% of the participants. Materials in general also shared strong similarity with the category stone: Both were frequently associated with the core terms “smooth,” “hard,” “rough,” and “soft”. Wood and leather also showed similar results: besides terms designating color aspects, they were both frequently associated with being “natural”. Unsurprisingly, there was little similarity between the categories metal and textiles. Whereas textiles were frequently associated with the haptic qualities “soft,” “fluffy,” and “scratchy,” metals were characterized by the visual terms “glossy” and its antonym “matte.”

Overall Mapping

Figure 2 depicts the two-dimensional MDS solution for the dissimilarity matrix using the Jaccard index. Further, based on the MDS coordinates of the terms and their frequencies in the categories, we calculated points that represent the localization of the categories and plotted them as vector arrows in the MDS plot.

Please insert Figure 2 about here

In the HCA, 23 low-level clusters emerged, and these appeared to be related to the specific natures of the various materials (see Figure S4 and Figure 2) and further depicted either antonyms, such as "light" or "heavy," or semantically similar words, such as "clear" and "see-through." The two-dimensional MDS (stress-1 = 0.24)[10] likewise revealed mainly material-specific characteristics. The horizontal dimension of the MDS plot distinguishes between terms referring to haptic qualities at the one end and terms referring to visual aspects on the other. The vertical dimension partly differentiates between adjectives describing the shape and appearance of materials and those that mainly denote economic value, origin, and processing possibilities. Furthermore, four clusters of material categories can be extracted (see also Figure S1 and Figure S2): The first comprises metal and stone, the second glass and ceramics, the third stone and metal, and the fourth wood and materials along with textiles and leather.

Discussion

Key Results

Today's designers have to satisfy aesthetic as well as emotional needs (Ashby & Johnson, 2003) as materials provide not only technical functionality but additionally convey meanings and elicit emotions (Ashby & Johnson, 2014). Following up on the approach used by Jacobsen et al. (2004), we explored survey participants' word usage for describing the aesthetics of various materials. Moreover, the results using a student subsample were successfully replicated using a

[10] A three-dimensional MDS resulted in a stress-1 of 0.17, yet we decided to retain the two-dimensional solution because the third dimension was not easily interpretable. Furthermore, permutation tests revealed a significant lower stress value for the two-dimensional solution for the original data as compared to the permutated data, indicating the existence of structure in the data.

broader cross-section of the population. The overall results allow insights into non-experts' collective conceptual structure of the aesthetics of materials and might help several stakeholders to deepen an understanding of materials experience.

The mean number of entries for materials in general, stone, and textiles were larger than for the other categories. Because the generic term "material" does not identify a specific material substance, but instead includes the multitude of substances that surround humans, the study participants in this specific category were given free rein for their thoughts and could associate terms with any specific material(s) that came into their minds through their imagination. Thus, unlike participants in the other categories, participants in this category could write down terms for several materials and not just one. Textiles, in turn, are specific materials with which people are confronted on a regular basis, especially in fashion. Therefore, it can be assumed that participants in this category used any of these instances to come up with aesthetic descriptions and/or judgements, regardless of whether they actually liked the clothes. The largest mean number of entries was produced for stone. A potential explanation might be the diverse uses of this material. As an essential building material, stone is used not only in the exterior architecture of houses and other buildings, but it is also relevant in interior design, such as floors, walls, or kitchen counters. Not surprisingly, the smallest number of terms, proportionally speaking, were produced for plastic. One the one hand, due to its unsustainability, this material has a rather negative reputation. On the other hand, Jacobsen (2006) claimed that the main philosophical and psychological conceptualization of aesthetics is beauty. As can be seen in the valence rating study we conducted, describing an entity as beautiful ascribes to it a clearly positive value. Thus, the attempt to incorporate plastic in an aesthetic frame might have led to a sort of cognitive dissonance, resulting in fewer terms being generated.

Altogether, the participants listed a large number of rather descriptive terms, for example, “smooth,” “hard,” “rough,” and “soft.” Needless to say, adjectives denoting sensorial qualities seem to play an enormous role in the aesthetic experience of materials and in their aesthetic evaluation. Unsurprisingly, in studies analyzing specifically artistic domains (Augustin et al., 2012; Istók et al., 2009; Knoop et al., 2016), more evaluative than descriptive adjectives were produced, particularly emotion-related terms. The term “beautiful,” for example, which is the primary and prototypical term for aesthetics in the other domains studied, is not one of the most relevant terms in the materials domain. Yet it ranked second for the category textiles, third for materials in general, and seventh across all categories, indicating that beauty, the classical notion for aesthetics, plays an important role in the aesthetics of materials as well. Unsurprisingly, this notion seems to be particularly preeminently associated with textiles, along with the opposite notion “ugly.” The presence of the bipolar “beautiful–ugly” concept for the category textiles, which was also primarily found for visual objects, might be in reference to clothing and fashion. Fashion trends potentially lead to an ideal of beauty (Jacobsen, 2006), and textiles, especially when used in clothing, are possible instruments for following the latest fashion. Clothing can in a sense be understood as a kind of second skin, which we not only get touched by or can see on ourselves but also see on others through our vision. Besides fulfilling certain technical functions, clothing should please our senses, and so it is very common to make an aesthetic judgment about it.

It is of particular note that adjectives referring to haptic qualities were the most frequently produced; for example, the words in the contrasting pairs “smooth–rough” and “hard–soft” were the most frequent words across all material categories. As previously mentioned, people find themselves in constant interaction with materials in their everyday lives, often through the haptic sense. This is different from the arts, where the sensory systems that are usually addressed

provide information from stimulus sources in the receiver's distant environment (*Fernsinne*) and it is usually not desired, or even possible, to touch the entity.

The sense of touch is the first sense to develop: Early in its development, an embryo can "contact" and "communicate" with the external world, and vice versa (e.g., Gallace & Spence, 2011; Montagu, 1984). Some authors even refer to tactile aesthetic experiences as being more primitive (from an ontogenetic point of view) than, for example, visual aesthetic experiences and speculate that visual aesthetic experiences might be founded on tactile aesthetics (Gallace & Spence, 2011). This way of communicating is tied to the body's largest organ: the skin (e.g., Montagu, 1984). That is, touch occurs in direct contact with the body (Etzi & Gallace, 2016)—or, as Sonneveld and Schifferstein (2008) noted, through touching something or someone, one will also be touched oneself, or what Gibson (1962) earlier defined as *active touch* and *passive touch*. This differentiates it from other senses as it is regarded the only sensory modality that can be divided into active and passive movement (e.g., Carbon & Jakesch, 2013). That is, exploring any kind of material actively, one "enters" into an aesthetic experience with the stimulus. As a consequence, this immediate feeling of touching and being touched might lead to strong personal experiences through this sense (Carbon & Jakesch, 2013). Already in early work by Herder (1778), the sense of touch was emphasized as a prominent sense, in this case for sculptures. But as can be seen in the present study's results, the haptic sense plays an essential role in far more aspects of life than aesthetics and artworks.

The terms "smooth" and "hard" were the most frequently mentioned words across all materials. In tactile perception, smoothness or its interrelated concept roughness (e.g., Bergmann Tiest & Kappers, 2006) as well as hardness are seen as the most important sensations for the assessment of surface structures and haptics (Howes et al., 2014). Roughness, in particular, is one

of the most important parameters of textured surfaces (Bergmann Tiest & Kappers, 2007; Hollins et al., 1993; Picard et al., 2003).

In addition to the adjectives that clearly depict haptic qualities, others are applied primarily to the visual sense, such as "glossy" or "colorful." Whereas Herder recommended in the eighteenth century that the sense of touch be revalued, as far back as 400 B.C., Aristotle (ca. 350 B.C.E./2017) arrived at the view in his treatise *De anima* that the sense of vision constitutes the top of the hierarchy of sense and the sense of touch the bottom. Some researchers today similarly suggest that various objects are perceived not only first but also foremost visually (Schifferstein, 2006; Schifferstein & Cleiren, 2005). In the materials domain, colors and related terms, such as "dark," "bright," "black," and "white," seem to be of great relevance in describing visual aspects. Others have already highlighted that color seems to be the most apparent visual aspect for distinguishing between materials and also the most researched visual aspect (Wastiels et al., 2012). Furthermore, results by Karana et al. (2009) suggest that colors are an effective sensorial property in attributing meanings to materials and products. As an example, products made of light, brightly, colored plastics conveyed a toy-like meaning, whereas dark colors were frequently associated with professionalism. Other authors have also argued that specific textures and temperatures of materials, that is, qualities experienced through touch, can be associated with colors (Silvennoinen et al., 2015). Additionally, as already noted, roughness is such an important surface property that both the visual and the haptic system must be able to perceive it (Bergmann Tiest & Kappers, 2007). Thus, some terms, for example, "coarse" and "edged," may be applied across both modalities.

It is conspicuous that words that describe experiences other than vision or touch were seldom mentioned. Even taking all of the terms mentioned into account, only a few words

referring to other senses were present, of which the number of adjectives referring to olfaction was largest.

Regarding the previously observed positivity bias of the terms mentioned to describe the aesthetics of various domains (Augustin et al., 2012; Istók et al., 2009; Jacobsen et al., 2004; Knoop et al., 2016), the results are slightly different for the domain examined here: The majority of the terms are evaluatively neutral, as measured by the additional valence rating study we conducted (59.4%). Still, among the remaining terms, participants showed a clear tendency to produce more positive than negative terms.

Along with the most commonly mentioned qualities overall or within the specific categories, the HCA and MDS showed the diversity and complexity of the characteristics associated with materials. These results reveal (a) not only common words for the various materials, as seen by the variety of cross-material terms, but also (b) material-specific words, which reflect the specific characteristics of the materials as well as (c) the connections between the different categories. Terms such as “rough” and “smooth” are of great relevance for a variety of materials, whereas others are clearly prototypical for specific materials, such as “scratchy” for textiles. The overall semantic map (see Figure 2) additionally highlights the similarity between the material categories with regard to specific concepts. For example, leather, textiles, and wood differ from ceramics, metal, and plastic with respect to warmth and softness (Ashby & Johnson, 2014). Prima facie, whereas ceramics and metal are based on mineral raw materials, leather, textiles and wood are mainly based on animal and vegetable raw materials (Marschallek & Jacobsen, 2020).

Furthermore, one end of the vertical axis of the overall semantic map displays terms referring to economic value, origin, or processing possibilities. Additionally, in contrast to the vertical axis, the horizontal differentiates between terms referring to haptic qualities at the one

end and terms referring to visual aspects on the other. The aesthetics of textiles and leather, for instance, was described by means of the haptic terms such as “smooth,” “hard,” “rough,” and “soft,” whereas ceramics and glass were often characterized using visual descriptors—for example, “glossy.” These differences may be due to specific occurrence of materials. Whereas individuals often necessarily need to touch or to be touched by textiles and leather—for example, incorporated in clothing—it is not always desired to touch products made of ceramics or glass—for example, decorative items. We suggest, however, that specific, more detailed reasons for differences between all categories warrant possibilities for future studies.

The frequency of the produced adjectives correlated with the frequency in general language use, reflecting the word frequency effect (e.g., Jescheniak & Levelt, 1994; Oldfield & Wingfield, 1965). However, general word frequency explains only about 25% of the variance of the frequency of the produced terms; thus the word frequency effect cannot itself completely explain the choice of terms in our study and the relative frequencies with which they were produced. The material categories and the produced adjectives represent an apt nexus. They yield commonalities, and specific differences that are not explainable by the frequency in general language use can fairly be considered as reflecting the conceptual structure of the aesthetics of materials. In reference to results by Augustin et al. (2012), who found significant correlations for, inter alia, buildings, cars, and textiles, the present finding was not surprising. As mentioned before, all kinds of materials are omnipresent in everyday life—for example, in the same categories being significant in the previous study. That is, other than for primarily artistic domains, for example, music, we suggest that individuals must not necessarily show specific interest to communicate their perceptions as well as evaluations of materials. Drawing upon adjectives frequently used in general language is therefore conceivable.

Limitations and Future Research

In the present study, we investigated the semantic field for the aesthetics of various materials for the German language. Thus, there are limitations regarding generalizations to other languages and cultures.

Also, situational aspects, such as the combination of a given time and place, might affect how objects are processed aesthetically (e.g., Jacobsen, 2006). Mentally stored scripts or schema concerning various materials might be activated as a function of situational variables. Would participants produce identical verbal associations if they all completed this task in a museum, for example? Additionally, background noises, such as other attendants talking, might have resulted in distracted or impaired concentration, leading to participants becoming less focused or unintentionally linking these noises with their conceptual associations.

Evaluative responses to entities also depend on the referential object category—for example, products. Since objects such as products are solely formed with materials, it might be that the concepts of materials depend on the products in which they are used. In the domain of colors, for example, evaluations can vary according to the levels of category formation, or internal representations (Whitfield, 1984). That is, participants might judge whether specific colors are consistent with their conceptual structures for the corresponding object categories—for example, whether they are appropriate. Furthermore, Desmet and Hekkert (2007) introduced a framework of product experience. The authors suggested three “components or levels” (p. 59) that are involved in a human-product interaction, each with having individual underlying processes: an aesthetic experience, an experience of meaning and an emotional experience. In the present study, however, the participants were not instructed to write down adjectives that could be used to describe the aesthetics of various materials in relation to specific objects, but they were free to associate. It may be assumed that some participants were automatically primed, either

consciously or unconsciously, to think of particular objects or products rather than of materials per se. In this case, they would write down product-dependent associations, that is, adjectives regarding the material in question as embedded in a specific object or product. As previous research has shown, house interiors made of wooden materials are described as warmer, more natural, cozier, more relaxing, and more inviting than, for example, ceramic interiors (Rice et al., 2006). In relation to the framework introduced by Desmet and Hekkert (2007), it may be interesting for future studies, whether the conceptual structures of materials are mediated by such a categorization process, that is, the domain of the material's eventual use. Alternatively, do our findings apply to materials without reference to the specific context? Ceramics, for instance, may be preferable in hot climate. The mentioned framework of product experience may then contribute to enrich the interpretation of the obtained data.

The relative small numbers of adjectives when a 5% or 10% cutoff is applied as compared to the large numbers when all terms listed are counted might arouse the conjecture that the conceptual structure for the aesthetics of materials is quite idiosyncratic. However, this type of pattern—a few terms listed by many participants, and many, many terms listed by only a few participants – is typical for free listing results, especially for so-called infinite or unbounded domains (Robbins & Nolan, 2019, and Weller et al., 2018, respectively). The most important results of free listing studies are the most salient terms as well as insights into the conceptual structure of a particular domain for a community of speakers of a language. The most salient words form the core of the conceptual structure but do by no means cover the entire conceptual structure, especially as there are marginally differences between persons due to individual preferences, experience and expertise. Nevertheless, the conceptual structure of the aesthetics of materials determined in this way is quite reliable, a as shown by the comparison of our two subsamples, which yielded quite similar conceptual structures (see online Supplemental Materials

S2, especially the common MDS and HCA in Figure S5 and Figure S6). While there are a few studies investigating the role of sample size (e.g., Schrauf & Sanchez, 2010; Weller et al., 2018) or the different ways in calculating a salience index (e.g., Thompson & Juan, 2006; Sutrop, 2001) we are not aware of a systematic examination of the effect of the cutoff on the reliability for found conceptual structure.

Many other interesting questions remain desiderata for future research. In order to overcome the limitations of the present study, cross-linguistic and cross-cultural comparisons are needed. Are the identified associations multilingual and multicultural? The "Classification of Material Substances" developed by Marschallek and Jacobsen (2020) is available in German and English, who strove to generate a classification that could be easily translated into other languages using mainly (international) standards. Thus, it would be interesting to analyze whether similar verbal associations are made in other languages and cultures.

Additionally, we strongly recommend considering a within-subjects design instead of giving only one material category per participant to complement the insights into the conceptual structure of the domain in question. Whether potential intraindividual differences or similarities regarding the conceptual structure of the aesthetics of the various materials might strengthen common as well as material-specific word production could be examined.

Furthermore, does expertise influence the conceptualization of the aesthetics of materials? Not only do cultures seem to differ in what is conceived as beautiful, for example, but within each culture, individuals can differ in what they consider beautiful (Jacobsen, 2010; Istók et al., 2009; Leder et al., 2019). Thus, rather than simply considering stimulus features, researchers may also want to consider a number of various vantage points, such as the participants who are processing the stimuli (Jacobsen, 2006)— for example, their expertise. The majority of participants in the present study did not consider themselves to be experts in the field of

materials. Thus, a systematical approach would seem to be interesting in this regard to clarify whether aesthetic responses are based on a common conceptual content that is modified by expertise (e.g., Istók et al., 2009).

Conclusions

Overall, our data suggest that the conceptual structure of the aesthetics of materials is diversified and rich, while showing a clear primacy of sensorial, neutrally valenced, descriptive terms. The term “smooth” turned out to be the most central term for all target categories, followed by “hard,” “rough,” and “soft.” Yet, although it by no means represented one of the most relevant terms, the word “beautiful” still proved its preeminence for the aesthetics of materials. Furthermore, our results clearly indicated that concepts being at the basis of materials aesthetics differ from other aesthetic domains. Thus, aesthetics, understood as a “sensation-based evaluation of an entity with respect to the . . . conceptual system, primarily the beauty dimension” (Jacobsen, 2006, p. 158), acquires a new importance in the domain of materials, since the pleasure gained through the perfection of sensory perception (Baumgarten, 1750–1758/2007) moves into the spotlight. We suggest that these insights might help several stakeholders to deepen an understanding of the aesthetic processing of materials. As designers, for example, aim to provide technical functionality as well as to create product personality, we hope that an integrated knowledge about the prevalence of materials’ sensorial attributes provides assistance in their choice of specific materials to create a product’s personality regarding, for instance, the naturalness of incorporated substances.

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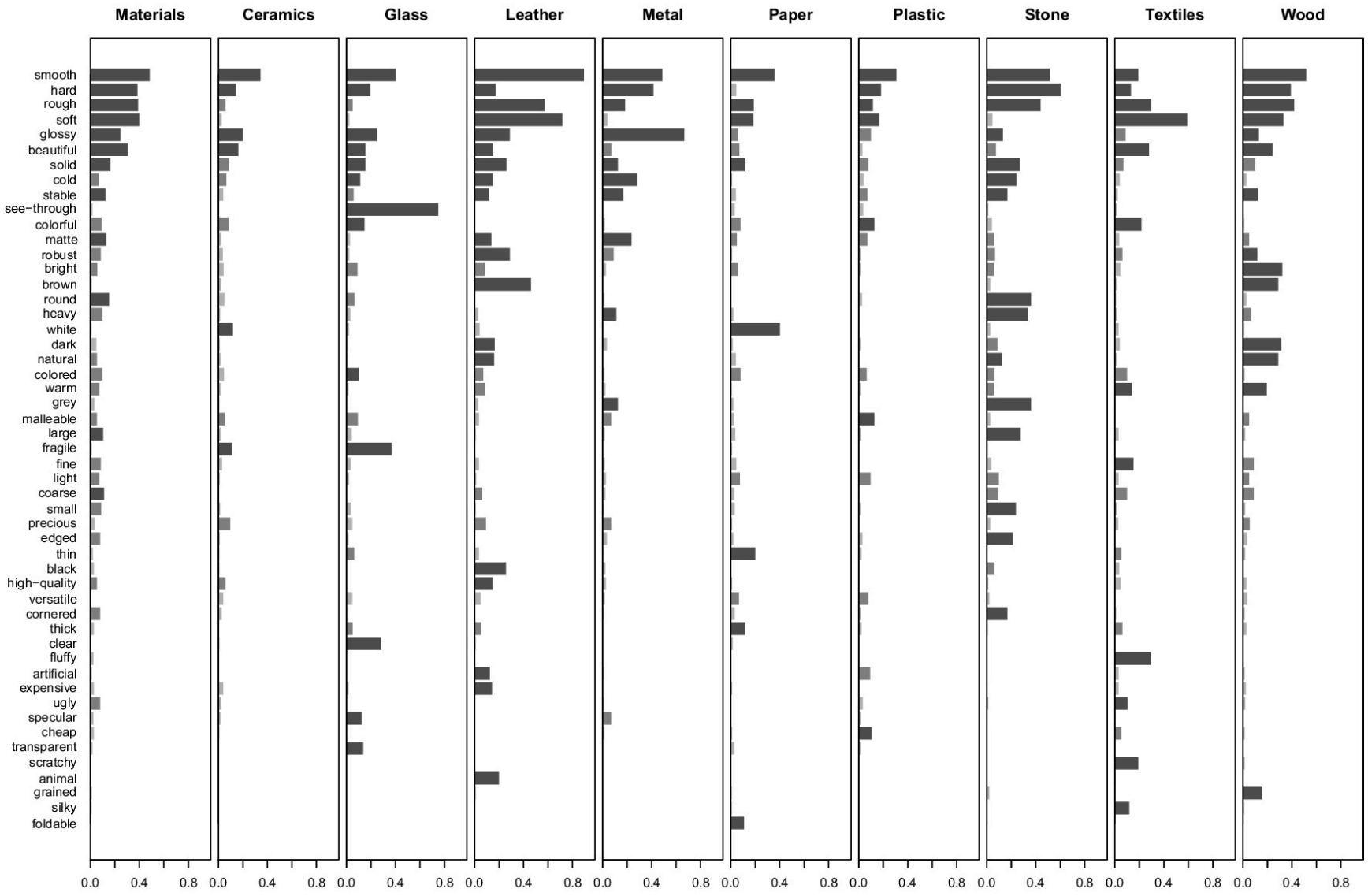
Materials
Ceramics
Glass
Leather
Metal
Paper
Plastic
Stone
Textiles
Wood
smooth
hard
rough
soft
glossy
beautiful
solid
cold
stable
see−through
colorful
matte
robust
bright
brown
round
heavy
white
dark
natural
colored
warm
grey
malleable
large
fragile
fine
light
coarse
small
precious
edged
thin
black
high−quality
versatile
cornered
thick
clear
fluffy
artificial
expensive
ugly
specular
cheap
transparent
scratchy
animal
grained
silky
foldable
0.0
0.4
0.8

Figure 1. Relative frequencies plotted for terms mentioned by at least 10% of the participants in one category, ordered by overall relative frequency in the sample. The bars indicate whether the term was listed by fewer than 5% (light grey), 5% to 10% (grey), or more than 10% (dark grey) of the participants in the individual categories.

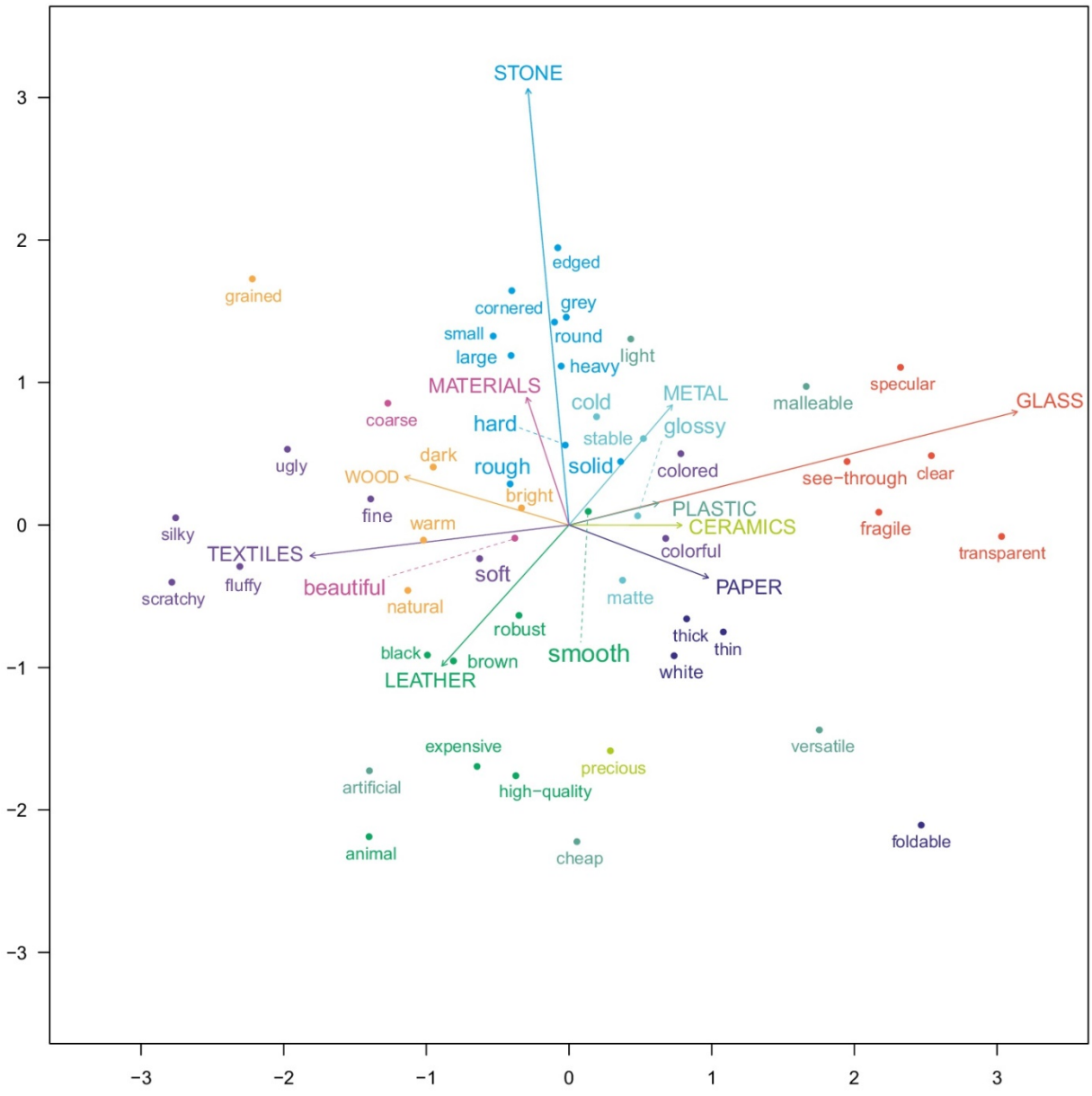

Figure 2. Two-dimensional multidimensional scaling solution. The 10 categories are marked with different colors, and their locations in the multidimensional space are indicated by the continuous vector arrows. The produced terms are coded by color indicating the category in which they had the highest relative frequency and varying font size showing their overall relative frequency. The location of the terms is indicated by dots; in the interests of readability, some word labels were moved in this figure as indicated by dashed lines.

Appendix

Instructions and Terms Listed

Original German instructions: “Bitte schreiben Sie Wörter auf, die man zur Beschreibung der Ästhetik von Werkstoffen verwenden kann. Bitte benutzen Sie nur Adjektive (Eigenschaftswörter). Sie haben ab jetzt 2 Minuten Zeit.”

For the different categories, the word *Werkstoffen* (materials) was replaced by the corresponding German word (*Keramik*, *Glas*, *Stein*, *Leder*, *Metall*, *Papier*, *Kunststoff*, *Textilien*, *Holz*).

Table A1

Terms Listed by at Least 5% of the Participants in One Category

Adjective	%	Valence 1	Valence 2	Frequency 1	Frequency 2
smooth (*glatt*)	45.1	n.a.	0.70 (1.01)	9.97	3
hard (*hart*)	26.7	-1.53	0.04 (1.20)	41.80	4
rough (*rau*)	26.4	n.a.	-0.73 (0.96)	1.16	3
soft (*weich*)	24.5	0.505	1.34 (1.04)	5.61	3
glossy (*glänzend*)	21.8	0.29	0.86 (1.00)	5.45	3
beautiful (*schön*)	15.4	1.27	2.07 (1.00)	94.54	4
solid (*fest*)	14.2	0.35	0.73 (0.99)	137.70	4
cold (*kalt*)	10.4	-1.865	-0.85 (1.15)	17.70	3
stable (*stabil*)	9.3	1.38	1.70 (1.00)	14.30	3
see-through (*durchsichtig*)	9.1	n.a.	0.52 (0.86)	1.25	2
colorful (*bunt*)	8.7	0.8	0.72 (1.28)	11.40	3
matte (*matt*)	8.1	n.a.	0.20 (1.22)	2.01	3
bright (*hell*)	7.6	n.a.	1.20 (1.06)	6.30	3
robust (*robust*)	7.6	1.14	1.40 (1.16)	2.48	3
brown (*braun*)	7.6	0.32	-0.41 (1.01)	3.32	3
round (*rund*)	7.3	0.47	0.37 (0.87)	531.10	4
heavy (*schwer*)	7.2	-0.56	-0.52 (1.07)	169.40	4
white (*weiß*)	6.8	0.4	0.40 (0.98)	n.a.	4
dark (*dunkel*)	6.8	-0.16	-0.09 (1.09)	8.90	3
natural (*natürlich*)	6.7	1.83	1.67 (1.08)	n.a.	4
colored (*farbig*)	6.6	n.a.	0.79 (0.99)	2.20	3
warm (*warm*)	5.9	1.485	1.57 (0.89)	13.80	3
grey (*grau*)	5.9	n.a.	-0.21 (1.05)	5.08	3
malleable (*formbar*)	5.8	n.a.	0.63 (1.05)	0.15	2
large (*groß*)	5.8	0.17	0.57 (1.00)	107.90	5
fragile (*zerbrechlich*)	5.7	n.a.	-0.90 (1.17)	0.90	2
fine (*fein*)	5.2	n.a.	1.26 (0.88)	11.00	3
light (*leicht*)	5.1	0.43	1.16 (1.00)	n.a.	4
coarse (*grob*)	4.9	-1.45	-0.94 (1.06)	6.73	3

small (*klein*)	4.7	-0.07	0.06 (0.99)	35.20	4
precious (*edel*)	4.7	0.49	1.79 (1.03)	1.62	3
edged (*kantig*)	4.4	-0.9	-0.48 (1.10)	0.52	2
thin (*dünn*)	4.2	n.a.	0.03 (1.09)	8.32	3
black (*schwarz*)	4.0	-0.42	0.17 (1.09)	15.43	4
high-quality (*hochwertig*)	3.9	n.a.	2.17 (1.02)	1.09	3
versatile (*vielseitig*)	3.8	1.76	1.53 (1.00)	3.68	3
cornered (*eckig*)	3.8	n.a.	-0.11 (0.77)	0.44	2
elegant (*elegant*)	3.7	n.a.	1.76 (1.02)	6.28	3
thick (*dick*)	3.7	-0.57	-0.83 (1.22)	8.96	3
supple (*geschmeidig*)	3.6	n.a.	1.48 (1.03)	1.35	2
clear (*klar*)	3.4	n.a.	1.27 (1.03)	n.a.	4
old (*alt*)	3.1	-0.35	-0.49 (1.14)	104.20	4
fluffy (*flauschig*)	3.0	n.a.	1.27 (1.27)	0.15	2
artificial (*künstlich*)	3.0	n.a.	-1.06 (1.06)	7.20	3
pure (*rein*)	2.9	0.39	1.48 (1.13)	n.a.	4
expensive (*teuer*)	2.9	-1.1	-0.82 (1.26)	36.80	4
ugly (*hässlich*)	2.9	-0.84	-2.22 (1.20)	2.02	3
modern (*modern*)	2.9	0.715	1.11 (1.13)	7.99	4
pliable (*biegsam*)	2.9	0.28	0.53 (0.94)	0.24	2
patterned (*gemustert*)	2.9	n.a.	0.01 (0.81)	0.36	2
massive (*massiv*)	2.7	n.a.	0.78 (1.15)	25.09	3
specular (*spiegelnd*)	2.7	n.a.	0.19 (0.94)	0.04	n.a.
brittle (*spröde*)	2.7	n.a.	-1.34 (1.22)	1.56	2
cheap (*billig*)	2.6	n.a.	-1.39 (1.31)	10.74	3
cool (*kühl*)	2.4	-1.2	-0.10 (1.18)	6.54	3
practical (*praktisch*)	2.4	1.155	1.79 (1.00)	n.a.	3
flexible (*flexibel*)	2.4	2.13	1.31 (0.92)	7.65	3
sanded (*geschliffen*)	2.3	0.13	0.74 (1.02)	n.a.	2
porous (*porös*)	2.3	n.a.	-1.27 (1.23)	0.33	2
sharp (*scharf*)	2.3	n.a.	0.17 (1.22)	18.5	3
strong (*stark*)	2.2	0.65	1.64 (0.97)	167.90	4
transparent (*transparent*)	2.1	0.28	0.52 (0.87)	5.43	3
pleasant (*angenehm*)	2.0	1.68	1.94 (0.83)	9.40	3
fibrous (*faserig*)	2.0	n.a.	-0.87 (1.01)	0.07	2
scratchy (*kratzig*)	2.0	n.a.	-1.70 (1.13)	0.09	2
colorless (*farblos*)	2.0	-0.76	-0.72 (1.12)	0.72	2
shimmery (*schimmernd*)	2.0	n.a.	0.69 (1.10)	0.15	n.a.
grained (*gemasert*)	1.9	n.a.	-0.05 (1.01)	0.01	n.a.
animal (*tierisch*)	1.9	n.a.	0.00 (1.09)	1.08	3
aesthetic (*ästhetisch*)	1.8	0.84	1.89 (1.03)	2.34	3
reflective (*reflektierend*)	1.8	n.a.	0.64 (1.04)	0.10	n.a.
flat (*flach*)	1.7	n.a.	-0.02 (0.72)	6.00	3
elastic (*elastisch*)	1.6	n.a.	0.57 (0.92)	0.60	2
polished (*poliert*)	1.5	n.a.	0.98 (1.06)	n.a.	2
pretty (*hübsch*)	1.5	0.91	1.94 (1.04)	4.90	3
pointed (*spitz*)	1.5	-0.46	-0.40 (0.92)	1.61	3
silky (*seidig*)	1.4	n.a.	1.20 (1.21)	0.16	2

liquid (*flüssig*)	1.3	n.a.	0.38 (0.87)	2.43	3
velvety (*samtig*)	1.3	n.a.	0.97 (1.09)	0.19	2
unicolored (*einfarbig*)	1.3	n.a.	0.11 (0.91)	0.28	2
rustic (*rustikal*)	1.3	n.a.	0.38 (1.06)	0.67	2
colorful (*farbenfroh*)	1.2	n.a.	1.14 (1.25)	0.80	2
tearproof (*reißfest*)	1.2	n.a.	1.27 (1.08)	0.07	2
gentle (*sanft*)	1.2	1.345	1.45 (0.91)	7.03	3
blunt (*stumpf*)	1.2	n.a.	-0.87 (1.08)	1.05	3
metallic (*metallisch*)	1.1	n.a.	0.24 (1.10)	0.43	2
milky (*milchig*)	1.1	n.a.	-0.52 (0.99)	0.15	2
foldable (*faltbar*)	1.1	n.a.	0.50 (1.03)	0.03	2
low-priced (*günstig*)	1.0	n.a.	0.74 (1.33)	14.23	3
stony (*steinig*)	0.9	n.a.	-0.88 (1.07)	0.74	2
lacquered (*lackiert*)	0.9	n.a.	0.11 (0.91)	n.a.	n.a.
real (*echt*)	0.8	n.a.	1.65 (1.00)	13.90	3
plastic (*plastisch*)	0.8	n.a.	0.00 (1.08)	1.51	2
silvern (*silbern*)	0.8	0.48	0.66 (1.01)	0.55	3
cuddly (*kuschelig*)	0.7	n.a.	1.66 (1.13)	0.45	2
translucent (*lichtdurchlässig*)	0.7	n.a.	0.65 (1.13)	0.05	2
polluting (*umweltschädlich*)	0.7	n.a.	-2.45 (0.99)	0.16	2
artistic (*kunstvoll*)	0.7	n.a.	1.23 (1.23)	3.34	3
rusty (*rostig*)	0.7	n.a.	-1.38 (1.15)	0.15	2
silver (*silber*)	0.7	n.a.	0.68 (1.01)	0.27	n.a.
woolly (*wollig*)	0.4	n.a.	0.52 (1.08)	0.07	2

Note. English translation, original German adjective (in parentheses), percentage of occurrence with respect to sample size, emotional valence, and frequency counts for the adjectives. Valence 1 was taken from Table 4.3 of Hager and Hasselhorn (1994) with anchors of -3 = *negative*, through O = *neutral*, to 3 =*positive*. Values were averaged if more than one was given; n.a. = value not available. Valence 2 indicates means and standard deviations (in parenthesis) from the additional valence rating study we conducted. Frequency 1 is the frequency per million wordforms given by COSMAS II; n.a. = authors decided to not include the value if the term could be also used other than as an adjective. Frequency 2 is the frequency category in Duden, with 5 representing one of the 100 most frequent words in the Dudencorpus and 1 representing a word that is not in the top 100,000; n.a. = value not available.