Human Ethology (2026), Vol. 41, 1-13.
DOI: 10.22330/001c.173022

POTENTIAL CUES FOR ATTRACTIVENESS IN INHERENT VISUAL CHARACTERISTICS OF NECKLACES

Marian Vanhaeren*[1], Pauline Mouclier[2], Bernd Riedstra[3], Petr Tureček[4,5], Barbara Schmidt[6], Ido R. Pen[3], Wulf Schiefenhövel[7,8]

[1]CNRS UMR 5199 PACEA, Université de Bordeaux, France
[2]Department of Archaeology, Leopold-Franzens-University of Innsbruck, Austria
[3]GELIFES, University of Groningen, Netherlands
[4]Center for Theoretical Study, Charles University, Czech Republic
[5]Department of Philosophy and History of Science, Charles University, Czech Republic
[6]Akademie für Gestaltung und Design, Handwerkskammer für München und Oberbayern, Germany
[7]Human Ethology Group, Max Planck Institute for Biological Intelligence, Germany
[8]Department of Psychology, Leopold-Franzens-University of Innsbruck, Austria

*marian.vanhaeren@u-bordeaux.fr

ABSTRACT

Many studies have focused on the attractiveness of physical characteristics of the human body, but few have examined extracorporeal attributes. This study investigated whether inherent visual characteristics of necklaces contribute to their attractiveness. Using questionnaires, preferences for nine visual variables were tested across three European regions (France, Germany and the Netherlands). Four variables were linked to the beads themselves (shape, color, shade, and size), and five concerned the overall visual appearance of the necklace (homogeneity, symmetry, contrast with background, number of strands, and length). Despite small sample sizes (N = 32 for France, N = 69 for Germany, N = 42 for the Netherlands), results across all three regions showed a consistent preference for single-strand necklaces composed of small, white, rounded beads arranged symmetrically and homogeneously on a relatively short string. No significant differences were found between female and male participants. These findings suggest a possible bio-psychological foundation for the appreciation of beauty and attractiveness in extracorporeal elements.

Keywords: beauty, aesthetics, beads, necklace, visual art

Submitted: 31 May 2025 · Revised: 3 September 2025 · Accepted: 6 November 2025

Physical characteristics, such as height (e.g., Stulp et al., 2013) or facial symmetry (e.g., Rhodes et al., 1998), play an important role for partner preference in humans. As choosing a partner has social and more importantly fitness consequences, previous studies have focused on the attractiveness of physical characteristics of the human body (e.g., Gangestad & Scheyd, 2005) and on the enhancement of these physical characteristics by permanent and non-permanent body modifications, especially body painting and make-up (e.g., Arai & Nittono, 2022). The specific characteristics of extracorporeal personal ornaments, such as necklaces, in relation to their inherent attractiveness have, however, not yet been studied in the same depth.

Decorating the body is a universal human behavior (e.g., Brown, 1991). Personal ornamentation can take permanent forms through modifying the human body by scarification, tattooing, anatomical interventions such as filing teeth, head- or feet binding, extending earlobes and lips, as well as circumcisions and perforations of various kinds. There are also many non-permanent modifications such as the wearing and applying of extracorporeal elements placed on the body; these include facial make-up, body painting, clothing, clothing accessories and jewelry of an astounding variety (e.g., DeMello, 2007). If made out of durable material, the latter show up in the archaeological record. A better understanding of the factors which make necklaces inherently attractive may therefore have important implications for interpreting archaeological data (e.g., Vanhaeren, 2014; Dapschauskas, et al. 2022; Nowell & Cooke, 2024; d'Errico, 2024).

Widespread extracorporeal personal decoration in the form of perforated ornaments made of durable materials possibly started between 150,000 and 100,000 years ago (e.g., Sehasseh et al., 2021 and references therein). The prevalent hypothesis for human personal ornaments is that they serve as an element of beautification of the body in courtship to attract the gaze of others and to raise the desired emotions in the perceiver, perhaps by providing information on the wearer's fitness and competences (e.g., Price, 1991; Miller, 2001; Vanhaeren, 2014; d'Errico, 2024). Necklaces, today's iconic personal ornaments, come in many different materials, colors, sizes, arrangements, and shapes (e.g., Dubin, 1987, 1999), but the question which type of necklace is most attractive, remains difficult to answer.

The ways in which animals and humans perceive the outside world have occupied thinkers from the early times of scientific approaches. Classical works such as Aristotle's *De Sensu* (translated into Latin) and the 11th century Arab philosopher Ibn al-Haytam's *Book of Optics*, which included pioneering visual experiments, laid foundational ideas in this domain. The physician, physicist and physiologist Hermann von Helmholtz (e.g., 1867) conducted groundbreaking studies on visual perception. His ideas, still discussed today, influenced the experimental psychologist Wundt (e.g., Wundt, 1862) and his student Titchener (e.g., Titchener, 1908), who applied structuralist ideas to understand the processes of visual perception in humans. On these grounds, the philosopher and psychologist Wertheimer (e.g., Wertheimer, 1922), his colleague Koffka (e.g., Koffka, 1935), and the psychologist and primatologist Koehler (e.g., Koehler, 1929) founded Gestalt psychology. It states that the whole of a visual impression is more than its individual elements, just as a painting is prima vista perceived in a holistic and thus more meaningful way than by perceiving depicted individual details. Gestalt perception explains visual deception, the figure-ground dichotomy, the perceptual addition of missing graphic elements and other neurobiological mechanisms highly relevant in the evolution of human visual perception (e.g., Eibl-Eibesfeldt, 1988). Advances in neurobiology and functional brain imaging (e.g., Sternberg & Sternberg, 2012), determining the brain regions where visual perception is transformed into the perception of "gestalts", namely in the temporal and parietal lobes (e.g., Bloechle et al., 2018), have partly replaced, but not disqualified these prior paradigms which have remained influential in various fields of research on visual perception.

Several principles which have been shown to be beneficial for the transmission and impact of visual information in visual arts, and to play a role in the production and perception of beauty, are: novelty and surprise, equilibrium between the parts and the whole (i.e., balance), symmetry, repetition, exaggeration, emphasis, movement, contrast (color play) and shared emotions (e.g., Wertheimer, 1922; Koffka, 1935; Arnheim, 1954; Collingwood, 1958; Rentschler et al., 1988; Eibl-Eibesfeldt, 1988; Dissanayake, 1980, 1992, 2009; Suetterlin, 1994; van Damme, 1996; Thornhill, 2003; Voland, 2003; Eibl-Eibesfeldt & Sütterlin, 2008; Dutton, 2009; Ishizu & Zeki, 2011; Changeux, 2012; Conway & Rehding, 2013; Bohrn et al., 2013; Krentz & Earl, 2013; Sütterlin et al., 2014; Prum, 2017; Bao et al., 2022; Mouclier et al., 2023). These principles, called "principles of art" (Arnheim, 1954; Collingwood, 1958; Verstegen, 2017) are often intertwined and interdependent. They are evident both in present day and ethnographically documented ornaments (e.g., Cole, 1975; Schoeman ,1983; Dubin, 1987, 1999; Sciama & Eicher, 1998; Mouclier et al., 2023, 2025) and can also be found, for example, in the ca. 75,000-year-old *Nassarius* shell ornaments from Blombos Cave (e.g., Vanhaeren 2014).

Studying whether communalities exist in modern-day attractiveness ratings of necklaces, according to several inherent characteristics, could point to the existence of some bio-psychological foundation in the perception, production, and appreciation of beauty and attractiveness (e.g., Hubel & Wiesel, 1962; Eibl-Eibesfeldt, 1988; Sütterlin et al., 2014) in extracorporeal elements today and in the past.

Here we report on the subjectively perceived attractiveness of different features of extracorporeal objects, in this case necklaces, used as decoration of the body.

METHOD

Participants

A total of N = 143 participants completed anonymously a Google Forms questionnaire. Thirty-two persons participated in France (22 women, 10 men, one of whom was colorblind), 69 in Germany (48 women, 21 men, none of whom were colorblind), and 42 in the Netherlands (25 women, 17 men, two of whom were colorblind). The first set of participants was recruited in and around the city of Bordeaux (France), within a circle of friends of a prehistory Master student during a period of one month in 2023. A second set was recruited in and around Munich, Germany, among a circle of colleagues, friends and students linked to the Bavarian chamber of crafts and design during two weeks in 2025 and, during a 24-hour period in 2025, a third set, this time biology students of the University of Groningen, who had participated in the course Biology of Human Behaviour over the past three academic years.

Stimuli

In the light of reported "principles of art" (cf. Arnheim, 1954; Collingwood, 1958), which can be traced back in the historic, ethnographic and archaeological bead records (cf. Vanhaeren, 2014; Mouclier et al., 2023, 2025), we distilled, from transcultural coffee table books on jewelry, nine visual variables: four linked to beads constituting a necklace (shape, color, shade, and size) and five concerning the visual aspect of the necklace as a whole (its degree of homogeneity as measured by number of pendants, symmetry, contrast against its background, its number of strands, and length).

In order to avoid biases, which could arise from the value of the presented beads or the physical characteristics of the person wearing them, we used beads made of clay as a "neutral" raw material and placed the necklaces onto "neutral" male and female grey human silhouettes to eliminate potential interferences linked to the face, skin color and clothing.

Subsequently, beads of different shapes were made, threaded, scanned, and digitally assembled in 49 necklaces displayed on grey human silhouettes grouped in 9 images (Figures 1 and 2). Each image contained five or six female and male silhouettes with necklaces designed to test one of the nine variables.

Figure 1.

Overview of the nine images with necklaces on human silhouettes displayed to participants one by one in order to evaluate their preference for particular bead shapes, colors or sizes, and necklace homogeneity, symmetry, contrast against the background, number of strands and strand length.

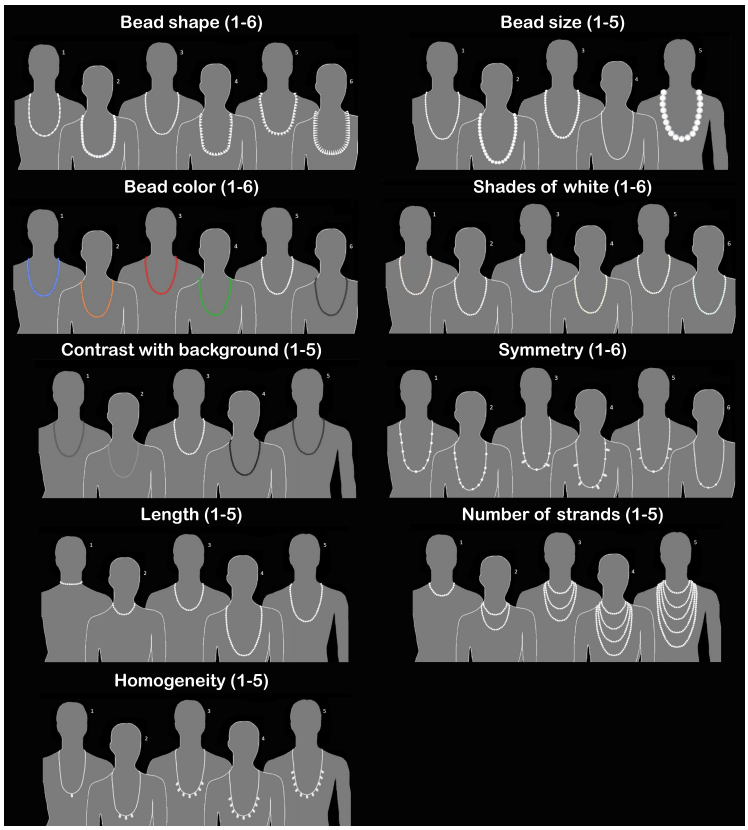
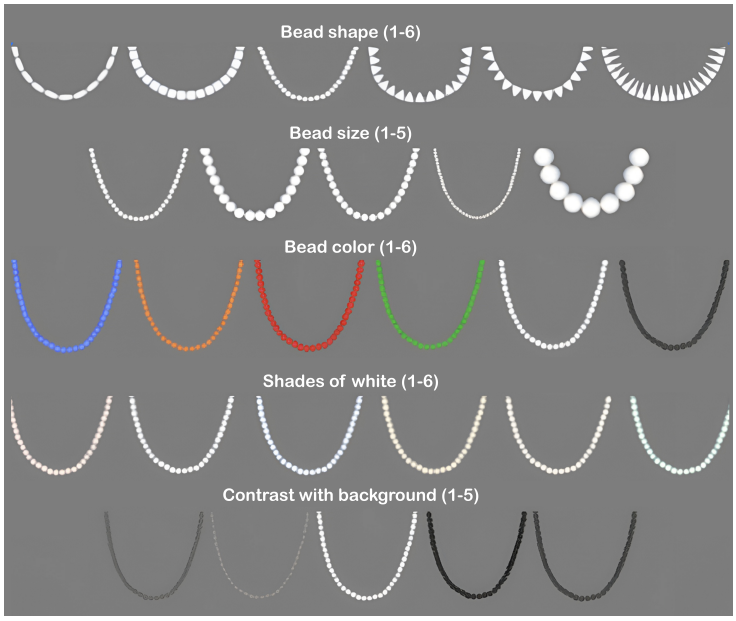


Figure 2.

Close-up views of necklaces displayed in the images to evaluate variables (shape, color, shade and size) linked to their constituent beads.



The necklaces presented featured elliptical, squarish, round, incisor-teeth-shaped and triangular-shaped beads, with the latter oriented either with point-inwards or point-outward. Bead colors comprised blue, orange, red, green, white, and black as well as five shades of white (reddish, red-bluish, bluish, yellowish, yellow-greenish, and greenish). To evaluate the role of contrast against the background, white, light grey, dark grey, very dark grey, and black beads were displayed on the grey silhouettes. Beads further came in five different bead sizes (from pea to walnut size). Five different necklace lengths placed them either tight around the neck, at the base of the neck, between the collarbone and the bust, on top of the bust, or below the bust. To evaluate the role of symmetry, larger beads and pendants were integrated in the necklace either in a symmetrical (i.e. equally spaced with one option displaying three and one option displaying 11 larger beads) or non-symmetrical way (i.e. one option with irregularly spaced larger beads, two options with irregularly spaced beads and pendants, and one option with regularly spaced beads and pendants of different sizes). Homogeneity was evaluated by necklaces integrating 1, 3, 7, 9, and 11 pendants in a symmetrical, equidistant way. Lastly, the attractiveness of necklaces composed of 1 to 5 strands was tested.

Procedure

The nine images were presented to the participants in a Google Forms questionnaire. Participants were asked to intuitively select the most attractive necklace from each image. The questions were presented in the participants' native language for French and German respondents, while Dutch students received the questionnaire in English.

Additionally, we asked two more questions. Firstly, given the existence of sexual dimorphism in humans, it could be that necklace characteristics were rated according to sex; in order to evaluate such potential differences, participants were asked whether they identified as a woman, man, non-binary person or preferred to make no statement. Secondly, we asked whether participants were colorblind in a general sense, which globally is the case in approximately 8% of men and 0.5% of women(e.g., Judd, 1943). This was done to correct for variation in the choices for necklaces including, color, shade and contrast.

Analysis

All data and code are available at: https://osf.io/7q3br.

Results were compiled in Excel and analyzed using *Past 4.0* (Hammer et al., 2001) and *R* (RCoreTeam 2024). Descriptive statistics and comparison with random choices were used to identify preferred necklaces. Bayesian multinomial logistic regressions, written for *Stan* infrastructure (StanDevelopmentTeam 2021) were used to identify the optimal grouping from the perspective of expected out-of-sample fit; Widely Applicable Information Criterion (WAIC) was calculated and compared across four grouping options: 1) none, 2) by sex, 3) by region, 4) by sex and region. Relative WAIC weights that sum to 1 and allow the prominence of groupings to be quantified on the same scale were calculated as follows:

$$w_i = \frac{e^{-0.5\Delta_i}}{\sum_j e^{-0.5\Delta_j}}$$

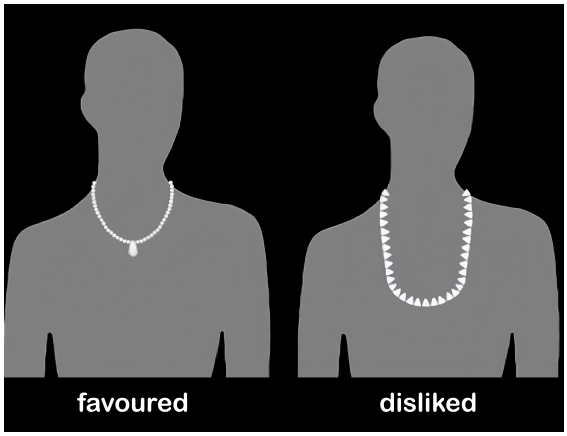
where Δ_i represents the difference between i^{th} model's WAIC and the lowest WAIC in the set (McElreath 2020).

RESULTS

Results are summarized in Figure 3 and Table 1. The necklace rated most attractive featured small to medium-sized white, rounded beads arranged in a short, symmetrical, homogeneous, single-strand design. The least-liked necklace was composed of triangular beads with one tip pointing inward. The "incisor teeth"- necklace was also poorly received. Additionally, necklaces with large beads, multiple strands, asymmetrical compositions, or extreme lengths (very long or tight around the neck) were rated unfavorably.

Figure 3.

"Portraits" of the most favored and disliked necklaces.



Although there was a tendency for men to prefer somewhat longer necklaces with slightly larger beads, and for women to choose double-strand necklaces more often than men—who more consistently preferred the single strand necklace—all participants showed similar preferences regarding bead shape (round), bead size (small), bead color (white), contrast with background (high), symmetry (clear symmetry), homogeneity (high) and single-strandedness. On average, participants of both sexes disliked longer necklaces, those with many strands or asymmetrical compositions, and those featuring large beads (see Table 1). Whether the necklaces were worn by female or male silhouettes did not appear to influence preferences; both male and female participants preferred necklaces worn on both types of silhouettes.

Twice, the model that distinguished participants by sex yielded the best expected out-of-sample fit: for bead color and number of strands. In particular, men did not like green; no single male participant chose this option. Female participants were more likely to prefer necklaces with more than one strand, although single-strand designs remained the most frequently selected across sexes.

Predictions for preferences regarding necklace symmetry, bead size, and bead shape benefited most from including the region variable. Across all regions, symmetrical necklaces were preferred. However, in France, participants favored designs with three symmetrically positioned larger beads, while German participants preferred those with 11. Dutch participants showed a balanced preference between these two options. In all regions, participants preferred small beads, with French participants favoring the smallest size, and German and Dutch participants more often opting for the second smallest. While small round beads were clearly preferred overall, German participants sometimes opted for square beads, and French participants were more likely to choose incisor-shaped beads.

Table 1

Preferred options for bead and necklace characteristics by region and sex, with model comparison

	France			Germany			Netherlands			Total				WAIC weight			
Variable / option	**F**	**M**	**Total**	**F**	**M**	**Total**	**F**	**M**	**Total**	**F**	**M**	**n**	**%**	**None**	**Sex**	**Region**	**Sex & Region**
Bead shape														0.20	0.20	**0.58**	0.02
(1) Elliptical	2	2	4	7	4	11	3	2	5	12	8	20	13.99				
(2) Squarish*	1	0	1	9	4	13	3	0	3	13	4	17	11.89				
(3) Round	**13**	**4**	**17**	**25**	**11**	**36**	**18**	**11**	**29**	**56**	**26**	**82**	**57.34**				
(4) Triangular, inward*	0	0	0	0	0	0	0	2	2	0	2	2	1.40				
(5) Triangular, outward	3	**4**	7	4	2	6	1	2	3	8	8	16	11.19				
(6) Incisor-shaped*	3	0	3	3	0	3	0	0	0	6	0	6	4.20				
Bead size														0.08	0.08	**0.83**	0.01
(1) Second smallest	6	2	8	**17**	5	**22**	**13**	**6**	**19**	**36**	13	**49**	**34.27**				
(2) Second largest*	2	0	2	9	3	12	0	2	2	11	5	16	11.19				
(3) Middle	5	3	8	12	**10**	**22**	6	**6**	12	23	**19**	42	29.37				
(4) Smallest*	**7**	**5**	**12**	9	2	11	6	3	9	22	10	32	22.38				
(5) Largest	2	0	2	1	1	2	0	0	0	3	1	4	2.80				
Bead color														0.03	**0.91**	<0.01	0.05
(1) Blue	3	0	3	7	2	9	2	2	4	12	4	16	11.19				
(2) Orange*	2	0	2	7	3	10	2	4	6	11	7	18	12.59				
(3) Red	2	0	2	6	2	8	1	0	1	9	2	11	7.69				
(4) Green*	4	0	4	10	0	10	1	0	1	15	0	15	10.49				
(5) White[a]	**7**	**7**	**14**	**14**	**13**	**27**	**14**	**9**	**23**	**35**	**29**	**64**	**44.76**				
(6) Black*[b]	4	3	7	4	1	5	5	2	7	13	6	19	13.29				
Shades of white														**0.85**	0.14	0.01	0.00
(1) Reddish	2	1	3	11	1	12	1	2	3	14	4	18	12.59				
(2) Red-bluish*[b]	**5**	2	**7**	7	2	9	**6**	2	8	18	6	24	16.78				
(3) Bluish	**5**	1	6	9	**10**	**19**	**6**	**6**	**12**	20	**17**	**37**	**25.87**				
(4) Yellowish*	4	1	5	**13**	4	17	5	3	8	**22**	8	30	20.98				
(5) Yellow-greenish[b]	2	2	4	4	2	6	**6**	3	9	12	7	19	13.29				
(6) Greenish*[b]	4	**3**	7	4	2	6	1	1	2	9	6	15	10.49				
Contrast with background														**0.96**	0.02	0.02	0.00
(1) Grey on grey	0	1	1	7	2	9	3	2	5	10	5	15	10.49				
(2) Light grey on grey*[b]	4	**3**	7	6	2	8	4	2	6	14	7	21	14.69				
(3) White on grey[a]	**12**	**3**	**15**	**19**	**12**	**31**	**13**	**10**	**23**	**44**	**25**	**69**	**48.25**				
(4) Black on grey*	3	1	4	10	5	15	3	1	4	16	7	23	16.08				
(5) Dark grey on grey	3	2	5	6	0	6	2	2	4	11	4	15	10.49				

Note. $N = 143$ (France: $n = 32$; Germany: $n = 69$; Netherlands: $n = 42$) for all variables. F = female participants; M = male participants. Highest value(s) per column within each variable group are shown in bold. WAIC weights sum to 1.00 for each variable; the weight for the best-fitting grouping model is shown in bold. * Necklace displayed on female silhouette. [a] Chosen by two colorblind participants. [b] Chosen by one colorblind participant.

Table 1 (continued)

	France			Germany			Netherlands			Total				WAIC weight			
Variable / option	**F**	**M**	**Total**	**F**	**M**	**Total**	**F**	**M**	**Total**	**F**	**M**	**n**	**%**	**None**	**Sex**	**Region**	**Sex & Region**
Symmetry														0.00	0.00	**0.99**	0.01
(1) 11 beads, symmetrical	4	2	6	**16**	**8**	**24**	6	**8**	14	26	**18**	44	**30.77**				
(2) 12 beads, asymmetrical*	3	0	3	9	2	11	0	1	1	12	3	15	10.49				
(3) 5 beads, 2 pendants, asymmetrical	3	1	4	2	1	3	0	0	0	5	2	7	4.90				
(4) 5 beads, 5 pendants, asymmetrical	2	0	2	10	4	14	1	0	1	13	4	17	11.89				
(5) 3 beads, 4 pendants, symmetrical	2	2	4	3	0	3	6	2	8	11	4	15	10.49				
(6) 3 beads, symmetrical*	**8**	**5**	**13**	8	6	14	**12**	6	**18**	**28**	17	**45**	**31.47**				
Necklace length														0.00	0.00	0.03	**0.97**
(1) Tight around neck	3	0	3	1	0	1	0	0	0	4	0	4	2.80				
(2) Base of neck*	**14**	3	**17**	18	5	23	**22**	7	**29**	**54**	15	**69**	**48.25**				
(3) Collarbone to bust	5	**7**	12	**20**	**9**	**29**	3	**8**	11	28	**24**	52	36.36				
(4) Below the bust	0	0	0	7	3	10	0	0	0	7	3	10	6.99				
(5) On top of bust	0	0	0	2	4	6	0	2	2	2	6	8	5.59				
Number of strands														0.31	**0.56**	0.10	0.03
(1) 1 strand	6	**6**	**12**	**26**	**13**	**39**	**13**	**12**	**25**	**45**	**31**	**76**	**53.15**				
(2) 2 strands*	**8**	3	11	14	5	19	10	2	12	32	10	42	29.37				
(3) 3 strands	5	1	6	3	1	4	2	1	3	10	3	13	9.09				
(4) 4 strands*	2	0	2	4	2	6	0	1	1	6	3	9	6.29				
(5) 5 strands	1	0	1	1	0	1	0	1	1	2	1	3	2.10				
Number of pendants														**0.81**	0.18	<0.01	<0.01
(1) 1 pendant	**8**	**6**	**14**	**25**	**13**	**38**	**15**	**12**	**27**	**48**	**31**	**79**	**55.24**				
(2) 3 pendants*	7	1	8	11	3	14	5	1	6	23	5	28	19.58				
(3) 7 pendants	3	1	4	3	3	6	3	0	3	9	4	13	9.09				
(4) 9 pendants*	1	1	2	4	0	4	2	1	3	7	2	9	6.29				
(5) 11 pendants	3	1	4	5	2	7	0	3	3	8	6	14	9.79				

Note. $N = 143$ (France: $n = 32$; Germany: $n = 69$; Netherlands: $n = 42$) for all variables. F = female participants; M = male participants. Highest value(s) per column within each variable group are shown in bold. WAIC weights sum to 1.00 for each variable; the weight for the best-fitting grouping model is shown in bold. * Necklace displayed on female silhouette.

Necklace length was the only variable where the grouping by both sex and region provided the best out-of-sample fit: both female and male German participants tolerated longer necklaces, while in the French and Dutch samples, female participants consistently preferred necklaces worn at the base of the neck and male participants preferred slightly longer designs. This trend was also observed in Germany, but due to a generally higher preference for longer necklaces, both sexes most often selected lengths falling between the collarbone and bust.

For contrast with background, number of pendants, and shades of white, the model treating all participants as a single group yielded the best out-of-sample fit. Participants across all three regions and both sexes clearly preferred highly contrasting white beads on a grey background and necklaces with a single pendant. As for shades of white, no systematic preferences emerged, though there was a slight overall tendency toward bluish or yellowish tones.

Notably, for several variables, the best out-of sample fits for sex, region or combined groupings were improved by distinguishing between participants' second or third choice. Overall, there was a high level of agreement on the most preferred option (see Table 1).

DISCUSSION

Results must be interpreted with caution due to the small sample size and selective pool of participants. They seem, nevertheless, to indicate that extracorporeal displays following the "principles of art" (e.g., symmetry, color play) are the most successful and are attractive to both women and men.

Notably, small white beads with a central pendant were particularly appealing to the participants in this study. It is striking that the oldest beadworks known from our prehistoric past—specifically, white and small *Nassarius* shell beads from Africa and Western Asia (cf. e.g., Henshilwood et al., 2004; Bar-Yosef Mayer, 2015; Sehasseh et al., 2021), sometimes accompanied by larger shell pendants (cf. e.g., d'Errico & Backwell, 2016; Bar-Yosef Mayer et al., 2020)—are of this exact type. In contrast, empirical evidence for the use of a wider variety of bead types and pendants only occurs in later archaeological, historical and ethnographic contexts (cf. e.g., Dubin, 1987, 1999; Vanhaeren & d'Errico, 2006, Rigaud et al., 2015). This increased diversity could be linked to an increase of socio-cultural factors determining the desirability of beadworks.

The dislike of triangular beads oriented toward the wearer could be linked to the aggressive connotation of sharp, pointed teeth patterns, which are universally perceived as negative (e.g., Uher, 1991; Eibl-Eibesfeldt & Sütterlin, 1992). Similarly, dislike for the incisor-shaped beads may be linked to the negative perception of their pointed roots facing the wearer.

Some surprising preference, such as French women preferring incisor-shaped beads or German women preferring green beads, may be explained by familiarity. French female participants were mostly recruited from archaeology classes and may have been familiar with prehistoric ornaments featuring animal incisor teeth. In contrast, German female participants came from a contemporary craft milieu and may have possibly been more sensitive to color and color play.

It would be interesting to include covariates linked to body size, e.g., male preference for slightly longer necklaces may be partially explained by sexual dimorphism in upper body proportions. Additionally, Dutch and German participants' preference for slightly larger beads compared to French participants may be due to differences in average height (see also the increased preference for middle-sized beads among German and Dutch men).

The question if and how attention, attraction (especially sexual attraction and desire) as well as the perception of bodily and general beauty may be interrelated and can be explained evolutionarily remains an important issue in human ethology and related fields. The present study aimed to contribute a novel approach by highlighting the role of archaeology and the

potential to diachronically correlate prehistoric and historic objects of beauty with present-day investigations. Signalling mechanisms, especially ones connected to mate selection via physical beauty (e.g., Gangestad & Scheyd, 2005) are likely to play an important role. The ubiquity and universality of body ornamentation (e.g., Brown, 1991; DeMello, 2007; d'Errico, 2024; Dubin, 1987; Erikson, 1993; Nowell & Cooke, 2024), is most parsimoniously explained as an evolved human trait (e.g., Eibl-Eibesfeldt, 1988). Evolved and thereby universal neurobiological mechanisms of visual perception can explain the similarities in the choice of raw materials, the shaping of beads and their possible bio-psychological effects on the ones who perceive the thus decorated person.

Future research, including brain imaging studies that explore the psychophysiology of visual perception and the attribution of inputs into "gestalts" (e.g., Bloechle et al., 2018), will help facilitate the understanding of how jewelry and body decorations are evaluated today and may have been evaluated by our ancestors, whose preferences are only accessible through archaeological remains. Further studies should also increase sample sizes, include non-WEIRD (Henrich et al., 2010) participants from diverse socio-cultural backgrounds and from different age classes, test in how far indicated preferences align with the participants actual choices of wearable necklaces for themselves (as opposed to those preferred for others), and find ways to integrate the success of non-tested principles such as familiarity and innovation, surprise, shininess, value of the objects, texture and color play as well as possible interactions with the wearer's physical characteristics, body painting, clothing, and accessories.

ACKNOWLEDGMENTS

The authors are grateful to members of the International Society for Human Ethology (ISHE), the Akademie für Gestaltung und Design, Handwerkskammer München und Oberbayern, the Biology of Human Behaviour course of the University of Groningen, the Master II students in Archaeology of the University of Bordeaux (2021-2022) and University of Tübingen (2023-2024) as well as to John Richer, Ton Groothuis, Annette Gouw, Reint and Dineke Geuze, Sibylle Wolf and Benjamin Schürch for the many interesting discussions on the topic of beads and beauty. Many thanks are especially due to all participants who dedicated their time and attention to the questionnaire.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

DECLARATION

We declare that all work herein is original and our own. All authors have reviewed and approved the manuscript for submission, and it is not being considered for submission elsewhere whilst it is under consideration for *Human Ethology*.

TRANSPARENCY

Marian Vanhaeren: Conceptualization (Lead), Formal Analysis (Lead), Data curation (Equal), Methodology (Equal), Supervision (Lead), Visualization (Lead), Writing – original draft (Lead), Writing – review & editing (Lead), Validation (Lead)

Pauline Mouclier: Conceptualization (Supporting), Formal Analysis (Supporting), Methodology (Supporting), Visualization (Supporting)
Bernd Riedstra: Data curation (Supporting), Methodology (Supporting), Writing – original draft (Supporting)
Petr Tureček: Formal Analysis (Supporting), Methodology (Supporting), Validation (Lead), Writing – review & editing (Supporting)
Barbara Schmidt: Data curation (Supporting)
Ido R. Pen: Methodology (Supporting)
Wulf Schiefenhövel: Conceptualization (Supporting), Writing – original draft (Supporting), Supervision (Supporting), Writing – review & editing (Supporting)

ORCID ID

Marian Vanhaeren https://orcid.org/0000-0002-0724-0539
Pauline Mouclier https://orcid.org/0009-0005-6512-9299
Bernd Riedstra https://orcid.org/0000-0003-3151-0743
Petr Tureček https://orcid.org/0000-0003-2118-9909
Barbara Schmidt https://orcid.org/0009-0002-5760-0296
Ido R. Pen https://orcid.org/0000-0003-2512-378X
Wulf Schiefenhövel https://orcid.org/0000-0003-1855-0257

REFERENCES

Arnheim, R. (1954). *Art and visual perception: A psychology of the creative eye*. University of California Press.

Arai, T., & Nittono, H. (2022). Cosmetic makeup enhances facial attractiveness and affective neural responses. *PloS One, 17*(8), Article e0272923. https://doi.org/10.1371/journal.pone.0272923

Bao, Y., Zhang, D., Zhao, Ch., Pöppel, E., & Zabotkina, V. (2022). An aesthetic frame for three modes of knowing. *PsyCH, 5*, 636–644. https://doi.org/10.1002/pchj.588

Bar-Yosef Mayer, D. E. (2015). Nassarius shells: Preferred beads of the Palaeolithic. *Quaternary International, 390*, 79–84. https://doi.org/10.1016/j.quaint.2015.05.042

Bar-Yosef Mayer, D. E., Groman-Yaroslavski, I., Bar-Yosef, O., Hershkovitz, I., Kampen-Hasday, A., Vandermeersch, B., Zaidner, Y., & Weinstein-Evron, M. (2020). On holes and strings: Earliest displays of human adornment in the Middle Palaeolithic. *PLoS One, 15*(7), Article e0234924. https://doi.org/10.1371/journal.pone.0234924

Bloechle, J., Huber, S., Klein, E., Bahnmueller, J., Moeller, K., & Rennig, J. (2018). Neuro-cognitive mechanisms of global Gestalt perception in visual quantification. *Neuroimage, 181*, 359–369. https://doi.org/10.1016/j.neuroimage.2018.07.026

Bohrn, I. C., Altmann, U., Lubrich, O., Menninghaus, W., & Jacobs, A. M. (2013). When we like what we know: A parametric fMRI analysis of beauty and familiarity. *Brain & Language, 124*, 1–8. https://doi.org/10.1016/j.bandl.2012.10.003

Brown, D. E. (1991). *Human universals*. McGraw-Hill.

Changeux, J.-P. (2012). Beauty in the brain: For a neuroscience of art. *Rendiconti Lincei: Scienze Fisiche e Naturali, 23*(3), 315–320. https://doi.org/10.1007/s12210-012-0192-2

Cole, H. M. (1975). Artistic and communicative values of beads in Kenya and Ghana. *The Bead Journal, 1*(3), 29–37.

Collingwood, R. G. (1958). *The principles of art*. Oxford University Press.

Conway, B. R., & Rehding, A. (2013). Neuroaesthetics and the trouble with beauty. *PLoS Biology, 11*(3), Article e1001504. https://doi.org/10.1371/journal.pbio.1001504

d'Errico, F. (2024). An integrated evolutionary scenario for the culturalization of the human body. In F. Manni & F. d'Errico (Eds.), *The Oxford handbook of the archaeology and anthropology of body modification*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197572528.013.1

d'Errico, F., & Backwell, L. (2016). Earliest evidence of personal ornaments associated with burial: The Conus shells from Border Cave. *Journal of Human Evolution, 93*, 91–108. https://doi.org/10.1016/j.jhevol.2016.01.002

Dapschauskas, R., Göden, M. B., Sommer, C., & Kandel, A. W. (2022). The emergence of habitual ochre use in Africa and its significance for the development of ritual behavior during the Middle Stone Age. *Journal of World Prehistory, 35*(3), 233–319. https://doi.org/10.1007/s10963-022-09170-2

DeMello, M. (2007). *Encyclopedia of body adornment*. Greenwood Press.

Dissanayake, E. (1980). Art as a human behavior: Toward an ethological view of art. *The Journal of Aesthetics and Art Criticism, 38*(4), 397–406. https://doi.org/10.2307/430321

Dissanayake, E. (1992). *Homo aestheticus: Where art comes from and why*. Free Press.

Dissanayake, E. (2009). The artification hypothesis and its relevance to cognitive science, evolutionary aesthetics, and neuroaesthetics. *Cognitive Semiotics, 5*, 148–173. https://doi.org/10.1515/cogsem.2009.5.fall2009.136

Dubin, L. S. (1987). *The history of beads: From 30,000 BC to the present*. Thames and Hudson.

Dubin, L. S. (1999). *North American Indian jewelry and adornment: From prehistory to the present*. Abradale Press.

Dutton, D. (2009). *The art instinct: Beauty, pleasure and human evolution*. Bloomsbury.

Eibl-Eibesfeldt, I. (1988). The biological foundation of aesthetics. In I. Rentschler, B. Herzberger, & D. Epstein (Eds.), *Beauty and the brain: Biological aspects of aesthetics* (pp. 29–68). Birkhäuser.

Eibl-Eibesfeldt, I. (1989). *Human ethology*. Aldine de Gruyter.

Eibl-Eibesfeldt, I., & Sütterlin, Ch. (1992). *Im Banne der Angst: Zur Natur- und Kulturgeschichte menschlicher Abwehrsymbolik*. Piper.

Eibl-Eibesfeldt, I., & Sütterlin, C. (2008). *Weltsprache Kunst: Zur Natur- und Kunstgeschichte bildlicher Kommunikation*. Brandstätter Verlag.

Erikson, J. M. (1993). *The Universal Bead*. W. W. Norton.

Gangestad, S. W., & Scheyd, G. J. (2005). The evolution of human physical attractiveness. *Annual Review of Anthropology, 34*(1), 523–548. https://doi.org/10.1146/annurev.anthro.33.070203.143733

Hammer, Ø., Harper, D. A. T., & Ryan, P. D. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica, 4*(1), Article 4.

Henshilwood, C., d'Errico, F., Vanhaeren, M., van Niekerk, K., & Jacobs, Z. (2004). Middle Stone Age shell beads from South Africa. *Science, 304*(5669), 404. https://doi.org/10.1126/science.1095905

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences, 33*(2–3), 61–83. https://doi.org/10.1017/S0140525X0999152X

Hubel, D., & Wiesel, T. (1962). Receptive fields, binocular interaction and functional architecture in the cat's visual cortex. *The Journal of Physiology, 160*(1), 106–154. https://doi.org/10.1113/jphysiol.1962.sp006837

Ishizu, T., & Zeki, S. (2011). Toward a brain-based theory of beauty. *PLoS One, 6*(7), Article e21852. https://doi.org/10.1371/journal.pone.0021852

Judd, D. B. (1943). Facts of color-blindness. *Journal of the Optical Society of America, 33*(6), 294–307. https://doi.org/10.1364/JOSA.33.000294

Koehler, W. (1929). *Gestalt psychology*. Horace Liveright.

Koffka, K. (1935). *Principles of Gestalt theory*. Harcourt, Brace & World.

Krentz, U. C., & Earl, R. (2013). The baby as beholder: Adults and infants have common preferences for original art. *Psychology of Aesthetics, Creativity, and the Arts, 7*(2), 181–190. https://doi.org/10.1037/a0030691

McElreath, R. (2020). *Statistical rethinking: A Bayesian course with examples in R and Stan*. CRC Press. https://doi.org/10.1201/9781315372495

Miller, G. F. (2001). Aesthetic fitness: How sexual selection shaped artistic virtuosity as a fitness indicator and aesthetic preferences as mate choice criteria. *Bulletin of Psychology and the Arts, 2*(1), 20–25.

Mouclier, P., Schiefenhövel, W., Schmidt, B., & Vanhaeren, M. (2023). Potential cues for attractiveness in the perception of personal ornaments. Human Ethology, 38(Suppl.), HES64. https://doi.org/10.22330/he/38/suppl

Mouclier, P., Schiefenhövel, W., & Vanhaeren, M. (2025). A study of a traditional Nassarius shell bead headband from the Mek culture, highlands of Western New Guinea: Ethnographic and archaeological perspectives. *Ethnoarchaeology, 17*(2), 1–38. https://doi.org/10.1080/19442890.2025.2523635

Nowell, A., & Cooke, A. (2024). Culturing the Paleolithic body: Archaeological signatures of adornment and body modification. In N. Gontier, A. Lock, & C. Sinha (Eds.), *The Oxford handbook of human symbolic evolution* (pp. 400–428). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780198813781.013.20

Price, S. (1991). Parure. In P. Bonte & M. Izard (Eds.), *Dictionnaire de l'ethnologie et de l'anthropologie* (pp. 560–561). PUF.

Prum, R. (2017). *The evolution of beauty*. Anchor.

R Core Team. (2024). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.r-project.org/

Rentschler, I., Herzberger, B., & Epstein, D. (Eds.). (1988). *Beauty and the brain: Biological aspects of aesthetics*. Birkhäuser.

Rhodes, G., Proffitt, F., Grady, J. M., & Sumich, A. (1998). Facial symmetry and the perception of beauty. *Psychonomic Bulletin & Review, 5*, 659–669. https://doi.org/10.3758/BF03208842

Rigaud, S., d'Errico, F., & Vanhaeren, M. (2015). Ornaments reveal resistance of North European cultures to the spread of farming. *PloS One, 10*(4), Article e0121166. https://doi.org/10.1371/journal.pone.0121166

Schoeman, S. (1983). Eloquent beads: The semantics of Zulu art form. *Africa Insight, 13*(2), 5–25.

Sciama, L. D., & Eicher, J. B. (Eds.). (1998). B*eads and bead makers: Gender, material culture and meaning*. Berg Publishers.

Sehasseh, E. M., Fernandez, P., Kuhn, S., Stiner, M., Mentzer, S., Colarossi, D., Clark, A., Lanoe, F., Pailes, M., Hoffmann, D., Benson, A., Rhodes, E., Benmansour, M., Laissaoui, A., Ziani, I., Vidal-Matutano, P., Morales, J., Djellal, Y., Longet, B., … Bouzouggar, A. (2021). Early Middle Stone Age personal ornaments from Bizmoune Cave, Essaouira, Morocco. *Science Advances, 7*(39), Article eabi8620. https://doi.org/10.1126/sciadv.abi8620

Stan Development Team. (2021). Stan modeling language users guide and reference manual. https://mc-stan.org

Suetterlin, C. (1994). Kunst und Ästhetik: Ein integrativer Ansatz aus der Sicht der Humanethologie. In W. Schiefenhövel, Ch. Vogel, G. Vollmer, & U. Opolka (Eds.), *Gemachte und gedachte Welten: Der Mensch und seine Ideen* (pp. 95–119). Thieme.

Sütterlin, C., Schiefenhövel, W., Lehmann, C., & Forster, J. (Eds.). (2014). *Art as behaviour: An ethological approach to visual and verbal art, music and architecture*. BIS-Verlag.

Sternberg, R. J., & Sternberg, K. (2012). *Cognitive psychology* (6th ed.). Cengage Learning.

Stulp, G., Buunk, A. P., & Pollet, T. V. (2013). Women want taller men more than men want shorter women. *Personality and Individual Differences, 54*(8), 877–883. https://doi.org/10.1016/j.paid.2012.12.019

Thornhill, R. (2003). Darwinian aesthetics informs traditional aesthetics. In E. Voland & K. Grammer (Eds.), *Evolutionary aesthetics* (pp. 9–35). Springer.

Titchener, E. (1908). *Lectures on the elementary Psychology of Feeling and Attention*. Macmillen.

Uher, J. (1991). On zigzag designs: three levels of meaning. *Current Anthropology* 32(4), 437-439.

Van Damme, W. (1996). *Beauty in context: Towards an anthropological approach to aesthetics*. Brill.

Vanhaeren, M. (2014). The beauty of beads: From prehistory to present day. In C. Sütterlin, W. Schiefenhövel, C. Lehmann, J. Forster, & G. Apfelauer (Eds.), *Art as behaviour: An ethological approach to visual and verbal art, music and architecture* (pp. 273–288). Bis-Verlag.

Vanhaeren, M., d'Errico F. (2006). Aurignacian ethno-linguistic geography of Europe revealed by personal ornaments. *Journal of Archaeological Science, 33,* 1105-1128. https://doi.org/10.1016/j.jas.2005.11.017

Verstegen, I. (2017). *Arnheim, Gestalt and art: A psychological theory*. Springer

Voland, E. (2003). Aesthetic preferences in the world of artifacts. In E. Voland & K. Grammer (Eds.), *Evolutionary aesthetics* (pp. 239–260). Springer.

von Helmholtz, H. (1867). *Handbuch der physiologischen Optik*. Leopold Voss.

Wertheimer, M. (1922). Untersuchungen zur Lehre von der Gestalt. *Psychologische Forschung, 1*, 47–58.

Wundt, W. (1862). *Beiträge zur Theorie der Sinneswahrnehmung* [Contributions to the theory of sensory perception]. Winter.