

# BeauVis: A Validated Scale for Measuring the Aesthetic Pleasure of Visual Representations

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# Aesthetics

• Aesthetic Pleasure

Osbert, Alphonse. (1908). *Soir Antique* [Oil on canvas]. Petit Palais, Paris.



#### **Aesthetic Pleasure (or Beauty)**

A pleasurable subjective experience that is directed toward an object and not mediated by intervening reasoning. [Reber et al., 2004]

Osbert, Alphonse. (1908). Soir Antique [Oil on canvas]. Petit Palais, Paris.

# Aesthetic Pleasure In Visualization

- Focuses on a visualization's visual appeal or beauty
- **NOT** related to how understandable, informative, or memorable it is

Do not need to understand the visualization's meaning or its data

# Aesthetic Pleasure

# An Important aspect of Visualization

- Affects usability and effectiveness [Cawthon & Vande Moere, 2007; Healey & Enns, 2022]
- Has the potential to communicate [Brath et al., 2005]

and to engage viewers

[Bach et al., 2013; Tateosian et al., 2007]

• Has been identified as one of the heuristics of some subfields

e.g., ambient visualization [Mankoff et al., 2003]

# How to measure aesthetic pleasure?

# Rating scales

#### A Rating scale measuring the aesthetic pleasure of websites [Lavie & Tractinsky, 2003]

 Construct
 To what extent do you agree or disagree or disagree with the following statements: The website has a/an \_\_\_\_\_.

 Factor(s)
 Strongly disagree

Factor 1: Classic aesthetics	aesthetic design
Rating items	pleasant design
hading items	clear design
	clean design
	symmetric design
Factor 2: Expressive aesthetics	creative design
Factor 2: Expressive aesthetics	creative design fascinating design
Factor 2: Expressive aesthetics	creative design fascinating design use of special effects
Factor 2: Expressive aesthetics	creative design fascinating design use of special effects original design



## Scales for measuring the aesthetic pleasure of ...

websites websites designed artifacts Available online at www.sciencedirect.com FI SEVIER Available at ScienceDirect Human-Computer International Journal of www.ElsevierComputerScience.com Human-Computer Studies Int. J. Human-Computer Studies 68 (2010) 689-709 PONESED BY BOIRNON CONSECT. Studies Int. J. Human-Computer Studies 60 (2004) 269-298 num demise comforatoliko Facets of visual aesthetics Morten Moshagen<sup>a,b,\*</sup>, Meinald T. Thielsch Assessing dimensions of perceived visual <sup>8</sup>Lebernahl Psychologie III, University of Manuheim, Schlasz, EO 254, 68133 Manuheim, Germany <sup>9</sup>University of Dasasolderf, Germany <sup>9</sup>University of Massater, Germany aesthetics of web sites Received 17 January 2010: received in revised form 1 May 2010: accepted 27 May 2010 Talia Lavie<sup>a</sup>, Noam Tractinsky<sup>b,\*</sup> Communicated by G. Lindgaan Available online 4 Jane 2010 Department of Industrial Engineering and Management, Ben Garion University of the Negev, PO Box 653. Beer Sheva 84105. Israel <sup>b</sup>Department of Information Systems Engineering, Ben Gurion University of the Neges, PO Box 653, Beer Sheva 84105, Israal Abstract Visual aesthetics has been shown to critically affect a variety of constructs such as perceived usability, satisfaction, and pleasure. Given Received 18 July 2003; accepted 17 September 2003 the importance of visual aesthetics in human-computer interaction, it is vital that it is adequately assessed. The present research aimed at the importance of visual associated and infinition and to develop a new measure of precived visual associated. In the precise neutral annexity and providing a precise operational definition and to develop a new measure of precived visual associated websites. Construction of the Visual Assthetics of Website Inventory (ViAWI) was based on a comprehensive and broad definition of visual assthetics of vebsites. Abstract were identified and validated in a series of seven studies. Simplicity and Diversity have repeatedly been treated as formal parameters of aesthetic objects throughout the history of empirical aesthetics, Colors are a critical property of aesthetic objects, and Craftsmanship Despite its centrality to human thought and practice, aesthetics has for the most part played addresses the skillful and coherent integration of the relevant design dimensions. These four facets jointly represent perceived visual aesthetics, but are still distinguishable from each other and carry unique meaning. The subscales contained in the VisAWI demonstrate good internal consistencies. Frieders for the convergent, divergent, discriminative, and concurrent validity of the VisAWI is provided. a petty role in human-computer interaction research. Increasingly, however, researchers attempt to strike a balance between the traditional concerns of human-computer interaction and considerations of aesthetics. Thus, recent research suggests that the visual aesthetics of Overall, the present research surgests that the VisAWI appears to be a sound measure of visual aesthetics of websites comprising facets of computer interfaces is a strong determinant of users' satisfaction and pleasure. However, the © 2010 Elsevier Ltd. All rights reserved. lack of appropriate concepts and measures of aesthetics may severely constraint future research in this area. To address this issue, we conducted four studies in order to develop a Knowed: Anthonics: Assessment: Beauty: Design: Measurement: Website measurement instrument of perceived web site aesthetics. Using exploratory and confirmatory factor analyses we found that users' percentions consist of two main dimensions, which we termed "classical aesthetics" and "expressive aesthetics". The classical aesthetics dimension 1. Introduction objective versus subjective distinction and adopt an pertains to aesthetic notions that presided from antiquity until the 18th century. These notions interactionist perspective: Beauty is seen as a function of emphasize orderly and clear design and are closely related to many of the design rules The question of what constitutes beauty has been given a both, properties of an object and characteristics of the variety of answers over the past centuries (e.g., Feagin and Maynard, 1997; Fenner, 1996; Osborne and Balakian, perceiver, that is, beauty emerges from patterns in the way advocated by usability experts. The expressive aesthetics dimension is manifested by the perceivers and objects relate. In line with this interactionis designers' creativity and originality and by the ability to break design conventions. While both nsions of perceived aesthetic are drawn from a pool of aesthetic judgments, they are 1968). Many theorists conceived beauty as a property of an viewpoint, the philosopher Santayana (1955) describes three defining features of beauty. Beauty is value positive, clearly distinguishable from each other. Each of the aesthetic dimensions is measured by a five object that produces a pleasurable experience in any perceiver. In contrast to this objectivist view, the subintrinsic, and objectified. Beauty is value positive, because item scale. The reliabilities, factor structure and validity tests indicate that these items reflect the two perceived aesthetics dimensions adequately. jectivist view proposes that anything could be beautiful as it provides pleasure. Beauty is intrinsic, because an object is long it pleases the senses. Beauty is regarded as a mere perceived without any reasoning about expected utility C 2003 Elsevier Ltd. All rights reserved. function of idiosyncratic qualities of the perceiver, rather This feature of beauty implies that aesthetic responses than being directly determined from attributes of an object. occur immediately at first sight, rather than being the result Most modern philosophical analyses, however, reject the of a long lasting cognitive analysis. Finally, beauty is objectified, because people experience beauty as something ° This study was supported by a grant from the Burda Centre for Innovative Communications at Benthat lies in an object, rather than exclusively being the \*Corresponding author at: Lehrstahl Psychologie III, University of Mannheim, Schloss, EO 254, 68133 Mannheim, Germany. Tel.: + 49 621 1812126; fas: + 49 621 1813997. *Erwail address:* monlanger@iuiimannheim.de (M. Moshagen). Gurion University of the Negev. \*Corresponding author. Tel: + 972-8-6472226; fax: +972-8-6477527. result of a positive sensation of the body. This is not to be confused with an objectivist viewpoint on beauty. Beauty is E-mail address: noamt@bgumail.bgu.ac.il (N. Tractinsky). not objective, but directed toward an object. 1071-5819/\$-see front matter () 2003 Elsevier Ltd. All rights reserved 1071-5819/S-see front matter 0 2010 Elsevier Ltd. All rights reserved doi:10.1016/j.ijhes.2010.05.006 doi:10.1016/j.ijhcs.2003.09.002

[Lavie & Tractinsky, 2003]

#### [Moshagen & Thielsch, 2010]

Psychology of Aesthetics, Cosativity, and the Arts 2017, Vol. 11, No. 1, 86–98 0 2017 American Psychological Association (\$11-3959717512.00 http://dx.doi.org/10.0073/aca0000098 The Aesthetic Pleasure in Design Scale: The Development of a Scale to Measure Aesthetic Pleasure for Designed Artifacts Janneke Blijlevens Roval Melbourne Institute of Technology University Clementine Thurgood University of Technology Sydney Paul Hakkart Lin-Lin Chen Delft University of Technology Eindhoven University of Technology Helmut Leder T. W. Allan Whitfield Swinburne University of Technology University of Vienna There is a lack of consistency regarding the scales used to measure aethetic pleasure within design. They are often chosen ad hoc or adopted from other meanersh fields without being validated for designed artificar. Menoreer, many acales do nor measure aethetic pleasure is isolation, but insead include its determinants (e.g., novely). Therefore, we developed a new scale to measure aethetic pleasure and included scales to measure its known determinants for discriminant validity purposes, which automatically led to validating these determinants as well. In the exploratory phase, we identified highly reliable items representative of aesthetic determinants as well. In the exploratory phase, we identified highly miledle menn representative of authoric phenome and is determinants across proceeding conjections. In which and the end of the end of the across different constitution (Antarian, the Pederlands, and Taiwas). The final scale consists of 5 menn, "boarding," attractive, "phonoing to over," ratios toos," and "the too look at," that tupber middley appress the construct of authorize phonon. Several recommendations are formalised regarding the application of this scale in todays makes and beyond. Research: aesthetic pleasure, desirn, scale development, determinants of aesthetic pleasure Research into aesthetic pleasure or appreciation is often con-fined to art perception and appreciation (Hekkert, 2014b). Al-the only "objects" that can be pleasant to look at, listen to, or though works of art are-or should we say "were"-often created touch. We can aesthetically appreciate a landscape or a photograph of that same landscape; we find beauty in faces, buildings, and other man-made things: we can even be aesthetically pleased by, and therefore ascribe beauty to, an idea, a chess move, or a scientific proof (Da Silva, Crilly, & Hekkert, 2015). Any object Jameke Bijlevens, Behavioural Business Lab, School of Economics, Finance and Marketing, Royal McIbourne Institute of Technology Univercan be aesthetically appreciated, and objects are often deliberately designed to induce aesthetic pleasure (Postrel, 2003). Accordingly we see an increasing interest in researching aesthetic pleasure sity: Clementine Thurpood, Design Innovation Research Centre, University: Clearantise Thargoed, Denja Isaovation Rosentz Octas, Usiro-joy et Technisology Shary, Tala Hoken, Department of Industrial Design Engineering, Deth Usiversity of Technisology: Lu-Lia Cae, Department Design of Physiches, Usirovity of Vortunes T. W. Alla Wildeld, Center for Design Isaovation, Switzmen Usirovity of Petrohology. Design of Physiches, Usirovity of Vortunes T. W. Alla Wildeld, Center for Design Isaovation, Switzmen Usirovity of Petrohology. 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While ample research into what people find aesthetically pleas niation for Scientific Research (NWG), availed to Fuel Hekkert. We would like to cepress our graintels to Wickster Hung and Yie Hank. Lee for transing the quadromain into Mandrat and displying that quadromain to the Tahaneau sample, Rohen Poor for its help which imagements, Rohen Poor (for the Science) and the Science Science and Science Science et al. (Science) and the Science Science Science Science Science Correspondence concerning this article should be addressed to Janacke ing exists in design, marketing, arts, and psychology literature (e.g., Blijlevens et al., 2012; Bloch, 1995; Hekkert, 2006, 2014a, 2014b: Hekkert et al., 2003: Hover & Stokburrer-Sauer, 2012; Loder, Belke, Oeberst, & Augustin, 2004; Loder, Ring, & Deosder, 2013; Schoormans & Robben, 1997; Swami, 2013; Veryzer & Hutchinson, 1998) research into how aesthetic pleasure for de-Bijlevens, Behavioural Basiness Lab, School of Economics, Finance and signed artifacts should actually be defined and subsequently be Marketing, Royal Melbourne Institute of Technology University, Building measured has received little attention. More specifically, in the 80, 445 Swanston Street, Melbourne, 3000, Victoria, Australia, E-mail:

[Blijlevens et al., 2017]

#### AttrakDiff Questionnaire

[Hassenzahl et al., 2003]

Pragmatic » Quality	
e.g. controllable	Assessment of Attractiveness
Hedonic » Quality	e.g. likeable
e.g. innovative – stimulation valuable – identity	

#### User Experience Questionnaire (UEQ)

[Schrepp et al., 2017]

interaction? Is it secure and

predictable?



product? Is it fun to use?

Does it catch the interest of users?

#### meCUE Questionnaire

[Minge et al., 2017]



# AttrakDiff Questionnaire [Hassenzahl et al., 2003] Pragmatic Quality Image: Marging Comparison C

# No validated scale

# targeted for measuring aesthetic pleasure in the visualization field

ins pro	2003 Ellevier Lid. All rights enserved. "The adaption of property of a grant from the In- Contex University of the Meyrs." "Comproving and the Meyrs." "Comproving and the Meyrs." In 972.64 (T220), for <i>Earlier adaption</i> : some first organization (N. Tr 1015-1018): A for the Meyrs." Cold Elevier Lid. / doi:10.1016/j.jbbc.2003.09.002	rda Conne for Internative Communications at Bos- et #32.6.467322. attinuity.	ntal	In the set of the starts, there is a sequence of the set of the start of the set of the	represents without any reasoning about expected utility: This future to hourisy infight that architect response to accur immediately at first ight, rather than being the result objectifed. These models are applied with the second second objectifed. These proper prepriets being that are applied with the second second second second second second second of that if up is an adjust, rather than exclusively hear the confident with an objectivit steppict the heart. Restry is not objective, but directed toward an object.	Bionai	show the studie's beauty (NW), and in the Malles We want the Stropping engineering with the Data put of the Malles We and the Stropping engineering and the Stropping and the stropping engineering and the Stropping and the Stropping engineering and the Stropping and the Stropping and the Stropping engineering and the Stropping and the Stropping engineering and the Stropping and the Stropping and the Stropping engineering and the Stropping and the Stropping and the Stropping engineering and the Stropping and the Stropping and the Stropping engineering and the Stropping and the Stropping and the Stropping engineering and the Stropping an	
	usefulness usability	visual aesthet status commitmen	ics it	negative emotions	intention to use	overall evaluation		

Likert scale between poor and excellent. For ants also indicated which image was better for a t hich image was more aesthetic, and which image ly. These questions were answered with one 5-p er image pair. The possible answers were clearly lef

[Jenny et al., 2021]	
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		Nauais	e
1	The visualization was enjoyable	3.75 (2.09)	5. (1.
	Using the visualization aid		

[Albo et al., 2016]

#### **Aesthetic Requirements**

Participants rated the display they were exposed to emantic differential scales. Participants rated predominantly Attractive, Beautiful, and Interesti vith no negative responses being listed in these ca one participant rated the display they saw during aseline visualization; (2) Ease/difficulty in understanding or comparison; (3) the aesthetic appearance of the des, we also asked for their general feedback.

#### esults

#### [Chen et al., 2021]

Memex was rated faster in terms of p e time (average rating of 5.7 v. 4.8 for Facetl terms of aesthetic appeal, FacetMap sco (average rating of 5.3 v. 4.1), t(18)=1.9, j user satisfaction ratings are provided in Tab

[Smith et al., 2006]

- Recunciant informative,
- Hindering Helpful,
- Boring Entertaining,
- Ugly Elegant.

We asked the participants to rate each c active features (i.e., cartogram-switching a Likert scale between poor and excellent. For ants also indicated which image was better for a t hich image was more aesthetic, and which image ly. These questions were answered with one 5-p er image pair. The possible answers were clearly lef e criteria: (1) Ease/difficulty in understanding aseline visualization; (2) Ease/difficulty in using r comparison; (3) the aesthetic appearance of the des, we also asked for their general feedback.

esults

# Self-selected terms: Not sure about the reliability or validity

#### .5 Aesthetic Requirements

Participants rated the display they were exposed to emantic differential scales. Participants rated predominantly Attractive, Beautiful, and Interesti with no negative responses being listed in these ca one participant rated the display they saw during

- Redundant miormative,
- Hindering Helpful,
- Boring Entertaining,
- Ugly Elegant.

We asked the participants to rate each c active features (i.e., cartogram-switching a

## BeauVis Scale

#### To what extent do you agree that this visual representation is ... ?



BeauVis scale in its recommended version

# Methods

#### Scale Development

#### Step 1: Term Generation $\rightarrow$ 209 Terms

- Literature Review
- Expert Suggestion

#### Step 2: Term Filtering → 31 Terms

- Filtering on Occurrence and Semantics
- Expert Review

#### Step 3: Exploratory Phase → Final Scale

- Crowdsourced Experiment
- Exploratory Factor Analysis
- Reliability Evaluation
  - Cronbach's Alpha

#### Scale Validation

#### Step 4: Validation Phase

- Crowdsourced Experiment
- Confirmatory Factor Analysis
- Reliability Evaluation
  - Cronbach's Alpha
- Validity Evaluation
  - Convergent Validity
  - Discriminant Validity
  - Differentiation by Known Groups

#### Step 1: Term Generation

## Literature Review: VIS Literature

#### Terms from 68 out of 3189 IEEE VIS, TVCG and CG&A papers

Is any veanesses of oour mages are not each miikert scale between poor and excellent. For ants also indicated which image was better for a t hich image was more aesthetic, and which image v ly. These questions were answered with one 5-p trimage pair. The possible answers were *clearly lef* image pair. The possible answers were *clearly lef*.

		Rauais	е
1	The visualization was enjoyable	3.75 (2.09)	5. (1
	[Albo et al., 2016]		

.5 Aesthetic Requirements

articipants rated the display they were exposed to emantic differential scales. Participants rated redominantly Attractive, Beautiful, and Interesti vith no negative responses being listed in these ca ne participant rated the display they saw during

[Rodgers and Bartram, 2011]

e criteria: (1) Ease/difficulty in understanding aseline visualization; (2) Ease/difficulty in using r comparison; (3) the aesthetic appearance of the des, we also asked for their general feedback.

#### esults

#### [Chen et al., 2021]

Solution of the set o

Kedundant - mormative,
 Hindering - Helpful,
 Boring - Entertaining,
 Ugly - Elegant.
 We asked the participants to rate each ctive features (i.e., cartogram-switching and the participant of the context of the second of t

#### Spreadsheet for collecting terms

journal	title	doi link	filename	searchterm	likert term	adjective: To what extent do you agree that this visualization is	likert term context	whether I saw the whole questionnaire[ source code) only papers I found relevent now.	excluded term	participant feedback	participant feedback context	path
TVCG	Evaluating Carlogram Effectiveness	https://doi.org/10.1109/TV CG.2016.2642109	07792176.pdf	Bioert;sesthetic;	??? (5-point: entertaining boring); ??? (5-point: elegent drab); ??? (5-point: innovative conventional);???(5-poi inteasy to understand);???(5-poi nt-browing magnitude clearlypoorly)	entertaining/boring/see gant/drab;innovative;c onventional;understan dable;clear;	cartograms;		helpful/hinderin gjinterested to use later;			
VIS	Chartern: Reviving Chart Images with Data Embedding	http://dx.doi.org/10.1109/T VCG.2020.3030351	111100a337	likert;aesthetic;	assifietic (5-point: high impact on a no impact at all on a.);	aesthetic;	how much the embedding patterns on background impact the overall aesthetic of the chart;					. /Vis-ell_full_p per_pdfs-text-e xtraction-result itrnfo/tis-202011 11100a337.tel. ml
VIS	FacetMap: A Scalable Search and Browse Visualization	http://dx.doi.org/10.1109/T VCG.2006.142	06_infovis_smit	questionnaireca esthetic;	aesthetic appeal (7-point?);	aesthetic;	score the three streamgraphs based on their aesthetic preference and perceived readability;	no	satisfication	like(the bridge metaphor);		. Vis-all_ful_pa per_pdfs-text-e xtraction-result /InfoVis-2006/0 6_infoVis-amith .tei.xml
VIS	Co-Bridges: Pair-wise Visual Connection and Comparison for Multi-liem Data Streams	http://dx.doi.org/10.1109/T VCG.2020.3030411	1111006612	Ekert;questionn aire;interview;a esthetic;	aesthetic appearance (5-point: nice, more or less nice, neutral, somwhat ugly, ugly);	aesthetic;nice;ugly;	For the aesthetic appearance, the users preferred Co-Bridges more.	no				Vis-all_full_pr per_pdfs-text-e xtraction-result /Vast-2020/111 00b612.tel.xml
VIS	SineStream: Improving the Readability of Streamgraphs by Minimizing Sine Illusion Effects	http://dx.doi.org/10.1109/T VCG.2020.3030404	1111006634	Exert;questionn aire;sesthetic;	aesthetic preference (7-point: totally disagree neutral totally agree);readability (7-point: totally disagree neutral totally agree);	aestheticyreadable;	streamgraph;					. /vis-all_full_p per_pdfs-text-e xtraction-result /infoVis-2020/1 11100b634.tei ml
VIS	The Influence of Contour on Similarity Perception of Star Glyphs	http://dx.doi.org/10.1109/T VCG.2014.2346426	2251_20tvcg12 -fuchs-2346426	likert;questionn aire;aesthetic;	aesthetic preferences(7-point: strongly prefered);	aesthetic;						Vis-all_full_p per_pdfs-text-e xtraction-result /InfoVis-2014/2 251_20tvog12- uchs-2346426. el.xml
VIS	Vis4Heritage: Visual Analytics Approach on Grotto Wall Painting Degradations	http://dx.doi.org/10.1109/T VCG.2013.219	13_vast_zhang	questionnaire;a esthetic;	aesthetic;visual design;	aesthetic;well-designe d;	tool;					. /vis-ell_full_p per_pdfs-lext-e xtraction-result /viset-2013/13_ vast_zhang.tei xml
VIS	Calliope: Automatic Visual Data Story Generation from a Spreadsheet	http://dx.doi.org/10.1109/T VCG.2020.3030403	111100a453	likert;questionn aire;interview;	aestheticness (5-point: worst best);expressiveness (5-point: worst best);understandability (5-point: worst best);	aesthetic;expressive;u nderstandable;	visualization;			satisfied nice design thought ul design;	,	. Nis-ell_full_pr per_pdfs-text-e xtraction-results /infoVis-2020/1 11100a453.tel ml
VIS	Vismate: Interactive Visual Analysis of Station-Based Observation Data on Climate Changes	http://dx.doi.org/10.1109/v AST.2014.7042489	5	questionnaire;a esthetic;	aesthetics (11-point: 0 10):visual design (11-point: 0 10);	aesthetic;well-designe d;	aesthetics - design of graphical user interface and visualization,vis ual design - of three views were suitable for analyzing domain tasks;	no				/Vis-all_full_pa per_pdfs-text-e xtraction-results /Vast-2014/I.tei xml
	automaniad Reality Graph	most (Mol oral10 1109M		cupation pains a	magrouping (Supplint)	anorthalic:						

## Literature Review: Literature from Related Field

Terms from 4 aesthetics-related scales development papers

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ELSEVER M. J. Basso-Computer Budge 50 (2014) 208-200 NRED verscherinzen/beat/date	www.dowie.com/took/jba Mi	zasure Aesthetic Pleasure for Designed Artifacts
	Facets of visual aesthetics	Ark Billeven Constitut Theorem A
Assessing dimensions of perceived visual	Merica Moshager <sup>107</sup> , Meinald T. Thielich <sup>1</sup> Volend Pachage R (income) of Markon Adv. At 20, 003 Markon formaty Pr	wi Hókur. Lin-Lin Chen
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<sup>1</sup> Department of Information Egenerating Rev Chains University of the Neuro, FO Rev Will, Rev Dates Mills, Load Revenues of the Index Networks (Net Computing Mill).	Allocat You and another to collect a first or a sector of possibility, which does, and phases, then	Is a bit of consistency specificg for solars and so constant and help phones which objects. They are shown at hims a subject from solar bits mounds fulfish solars bits or subject for adaptive orders, some, many solars in an ensumer analysis (phones in a indicate, how instant) include in a determinant mound of the solar and the solar analysis of the solar analysis of the solars of the solars in the solar analysis of a solar mounter analysis (phones in a indicate, how instant) include in a determinant mound of the solar analysis of the solars of the solars of the solars of the solars in the solars of the solars o
Noored In Fey 200, sooped In September 200	decimperature of visual analysis in human computer internation, it is into data it is adopted yourseld. The present meansh atomat at providing a provision approximation and to diversity a new meaners of provision it and address of the theory of the Tomat Audatesian of Human (Human Human) (Human Human) and address of visual and address on their time of the times of the second	accessly, therefore, we developed a new scale to measure another present and resided scales in an interaction terms of the foreignment of the property on the data strandsky that is subled at grant terms as well in the sublement plane, we detected by which a strandsky that is another on which datasets cover present singlexits. But a databaset we
Advanced Theories in controller to honors through and envertise, anothering has for the must next inleased	seeling instructs wald scopiedy dearbit the dools of instruct. Foot instructed facts of pocoeff visual andmiss of webbin were identified and valuated is a work of end was under. Kindly and Disensity have requested to fill theme presention of searbaric objects throughout the history of empirical anotheris, Colors on a critical paperty of andmiss alars, and Cathemandap	<ul> <li>- aBlown souther locating to Solidation, and Talward, The find water context of 3 team, and "structure" "Southing to see", "Into the set," of the to test of the structure studyed studyed and set of services glowers. Theread increases and along a transmission of the structure of the structure of these structures.</li> </ul>
a pelly role in human-computer instantion research. Accuratingly, however, instantion alongs in stalks a human-between the transformal ensurement of human-computer interaction and consolidations of ambeing Theorement memory memory for the starter instantion.	and/order. Not see that that independent of the freedom steeps methods, then the data and provide proteins protein and a set of the steep of the set of the steep of the set of	andr anderis planes, design, and developmen, determinant of anderie planese
and considerations of associate. This, return behavior suggest that the stand associate of everypeier investments is a strong determinent of source's surfacetaries and pleasare. However, the lack of appropriate encouper and measures of authorize may severally constraint future	Note of the second seco	phases or approxime to effect co- to delaye the postation of New yes dearby the second second
research in this area. To address this issue, we concluded lines it tables in order to develop a measurement instrument of prevalend with site andhorius. Using registratory and conferences y factor analyses we found that users' provpilens could of two main dimensions, which we	Kyunik Ankele Ankele Kurya Kur	4 deads we up "war"—offse classes indit. We can another off-properties a balance or a phonograph of the same badacque: we find house in teach, balance, building, and other same badacque: we can rest be another balance for the same badacque we can rest balance balance for the same badacque we can rest balance balance balance balance of the same balance balance balance balance of the same balance balance balance balance balance balance balance of the same balance balance balance balance balance balance balance of the same balance balance balance balance balance balance balance balance balance of the same balance balance balance balance balance balance balance of the same balance b
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charly distinguishable from each other. Each of the anotheric dimensions is measured by a fre- item used. The trilledilities, faster structure and validity isnis induste that these items reflect the two resourced anotheria diversions advected another.	adjest dan produces a pleasandle experience in any provident les sentenai in this objectivit sizes, the sub- pacified two proposed in applique could be benefit as a provident two provident applique could be benefit as a provident two provident pleasand and adjectified. Receip is subservation, fensione an object in provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be benefit as a provident two proposed in the specified could be provident to provide the provident two proposed in the specified could be provident to provide the provident two proposed in the specified could be provident to provide the provident the specified could be provided to provide the specified be provident to provident to provide the specified benefit to provide the	anty of Vanie, T. W. Alan Wathal, Fundame Encourse of Tahmang, and RECE research on Edition, Margin & Echary Mathematic Encourse of Tahmang, and RecElection and RecElection and RecElection and RecElection Mathematical Sciences and RecElection and RecElection and RecElection Mathematical Sciences and RecElection and RecElection and RecElection (1999). And RecElection and RecElection and RecElection and RecElection and RecElection (1999). And RecElection and RecElection and RecElection and RecElection and RecElection and RecElection (1999). And RecElection an
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[Lavie & Tractinsky, 2003]	[Moshagen & Thielsch, 2010] [Blijl	evens et al., 2017]
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Pragmatic 🔊		
Quality		
quoting		
	A	
	Assessment or	
e.o. controllable	A	
-	Attractiveness	
Hedonic		

e.q. likeable

Quality

e.g. innovative – stimulation valuable – identity

#### Spreadsheet for collecting terms

	AttrakDiff	Blijlevens, 2017	Lavie, 2003	Moshagen, 2010
aesthetic		aesthetic	aesthetic	
appealing	repelling/appealing	appealing		appealing
attractive	attractive	attractive		attractively positioned;attractive;
balanced				balanced;there are too many elements in
beautiful		beautiful	beautiful	
clean		clean	clean	
cluttered				
creative	creative	creative	creative	creative
elegant				
harmonious			harmonic	
inviting	inviting	inviting		
modern			modern	modern;contemporary
nice		nice		
organized			organized	pleasantly organized
bebeoheve			overloaded	overloaded
pretty		pretty		
tasteful			applies good taste	
vell-designed		designed	skilfully designed	
artistic			artístic	
boring	dull		dull	boring
delightful		delightful		
engaging				
enjoyable			enjoyable	
entertaining				
exciting		exciting	exciting	
fascinating		fascinating	fascinating	
good	good	good		
olor-harmonious				
interesting		interesting		interesting;lacks interesting design details
ikable	likable	like		
notivating	motivating	motivating		
pleasing	pleasant	pleasant;pleasurable	pleasing;pleasant	a pleasant effect
professional	professional/unprofessional	professional	professional	professional
provoking				
satisfying				
sophisticated		sophisticated	sophisticated	
lovely				
dynamic		dynamic		dynamic
crowded		density		crowded;too many elements
drab			monotonous	monotonous
high-quality		confers quality		
stylish	stylish			
vell-proportioned				well proportioned
nformative				
olorful			colorful	colorful;too few colors
eve-catching				

# **Expert Suggestion**

#### Invitation email sent to 57 visualization experts

Subject: Survey Invitation - How to Judge the Aesthetics of Visualizations?

To: [email of an expert in visualization]

#### Dear [expert's name],

We are currently working on a research project about generating a validated scale for rating the aesthetics of a visualization. An important step in the generation of a scale is to elicit terms from experts. Given your expert status in our domain we would much appreciate it if you could spend 2-3 minutes of your time and fill out our short survey.

To participate, please access the survey here:[survey link]

Please notice that this study has a two-stage evaluation process. After this survey, we would like to contact you again for a second very short survey.

We thank you a lot in advance and would be happy to share the results of our work with you if you are interested! Just let us know.

Best regards, Tingying He, Petra Isenberg, Raimund Dachselt, and Tobias Isenberg

#### Survey for collecting terms (31 responses)

You decided that you want to ask people to rate the visualization using a 7-point scale like the one below.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

Your task is to find good terms with which to capture this subjective opinion of participants about the aesthetics of the visualization. This means: you really only care about what the visualization looks like and NOT about how well people understand the data that it visualizes. So you decide to ask:

To what extent do you agree or disagree with the following statement: This visualization is \_\_\_\_\_\_.

Which terms would you put in the blank? Give us as many alternative terms as you can think of, but please give us at least 3 terms related to aesthetics.

This is the last question in this survey. Please take at least a minute to think about your answer before clicking "Next". Thank you.

Term 1	
Term 2	
Term 3	
Term 4 (optional)	
Term 5 (optional)	
Term 6 (optional)	
Term 7 (optional)	
Term 8 (optional)	

If you have any comment or additional terms, please put them here

#### Step 1: Term Generation

# 209 Terms

aesthetic	emotion	cognitive	data-aesthetic
a poor visual focus	alienating	a poor visual focus	expressive
aesthetic	appealing	appropriate	informative
appealing	appreciating	attention-catching	suitable
artistic	averageness	categorizable	
asymmetrical	awe	challenging	
attractive	boring	clear	other
awesome	bring me closer to people/separates me	cluttered	a printing effect
	from people		1 0
balanced	calm	compelling	admirable
beautiful	comfortable	comprehensible	alive
bold	connective	conceptless	amateurish
calm	cool	confusing	bad
captivating	delightful	contemplative	botched
cautious	desirable	cumbersome	cheap
clean	disgreeable	easy to grasp	colorblind-safe
cluttered	disturbing	elicits associations	consistent
color-harmonious	dynamic	informative	convenient
colorful	elation	inspiring	convenient
complex	emotive	interpretable	conventional
conservative	energetic	intuitive	easy on eyes
ontrastful	engaging	meaningful	easy orientation
conventional	enjoyable	memorable	easy to navigate
reative	entertaining	practical	easy to use
risp	evocative	readable	fauvist
rowded	evoking feelings	slick	fit together
iscouraging	exciting	stimulating creativity	flowing
istinctive	fascinating	stimulating curiosity	fluent to process
rab	favorable	straightforward	good
legant	fun	structured	hectic
xpressive	gratifying	undemanding	high-quality
ye-catching	happy	understandable	human
amiliar	hideous	use of color is successful	innovative
geometric	integrating		it is possible to discover new things even
			when looking at the page for a longer
	interes.		time.
as enough free space	interesting		noisy
as chough free space	intriguing		one sided
luminating	intruciva		pleasantly animated
nummating	isolating		preasantly animated
nnovalive	likehle		premium
nventive	Inkable		professional
uviung	mouvaung		resuess
ust eye-candy	moved		romantic
ack imagination	perfection		snows complete ignorance of numan vi-
ooks great, but does not enable to get	pleasing		some elements seem out of place
insight	positive		sophisticated
made with care	powerful		static
nodern	predictable		stucco
nice	preferable		technology
novel	provoking		the control instructions are too statio
ald-fashioned	relaxed		the number of images is adequate
nd-rasmoneu ordarly	estiefuing		the name contains too much test
rdinary	stimulating		too little happens on the page
ranized	summaning		unique
ngamzeu	sulking		unque
verloaded	the page changes too little due to user		uses special effects
venoaucu	actions		uses special circus
ainterly	thrills or chills		varied
batchy	touched		versatile
presentable	warm feeling		well-combined
pretty			well-finished
realistic appearance			wretched
rejecting			
simple			
streamlined			
stunning			
stylish			
symmetrical			
tacky			
tasteful			
thoughtful			
brown together			
nelv			
inimaginative			
unique			
in-to-date			
p-to-tate			
nlaar			
well-crafted			
vell-designed			
vell-proportioned			
nen proportioneu			

## Filtering on Occurrence and Semantics

6 Objective Criteria by Authors

- 1. The terms needed to be **related to** *aesthetic pleasure* rather than *understanding* or *comprehension* of a visual representation or its data (e.g., we excluded "informative," "clear," or "confusing").
- 2. The terms had to have **appeared at least twice** in one of the three resources we used for our item generation: visualization papers, other relevant aesthetics scale papers, or expert suggestions.
- 3. The terms should be **usable in a rating scale** and have a **clearly good or bad connotation** (e. g., we excluded "complex" because a complex aesthetic could be seen as positive or as negative).
- 4. The terms should be **easy to understand** (e.g., we excluded "consistent" because it would be unclear according to what aspect a visual appearance would be consistent) and their **interpretation should be clear** (e.g., we excluded "novel" because it would require people to know what "old" visualizations look like; we also excluded "drab" as a rare term that is not easily understood by many non-native speakers of English).
- 5. The terms had to **clearly apply to an assessment of a visual representation** (e. g., we excluded "dynamic" because, within visualization, the term may be read as referring to the property of being animated or interactive, rather than a dynamic aesthetic).
- 6. The terms should **not be pairs of opposite adjectives**. We only retained negative terms that did not have a clear positive opposite (e. g., we excluded "ugly" as the opposite of "beautiful").

#### Step 2: Term Filtering

# Expert Review

#### Invitation email sent to 56 visualization experts

Subject: Invitation for new short 4min survey - Terms to judge the aesthetics of a visualization

To: [email of an expert in visualization]

#### Dear [expert's name],

You have previously received an email from us about a first quick survey regarding how to judge the aesthetics of a visualization. If you had a chance to participate, thank you very much! We received a lot of useful input and comments that we will address! If not - don't worry - you still have a chance to participate in this second survey.

To clarify, our project is about developing a simple instrument to gauge the aesthetic pleasure of a visualization – meant to provide a few simple rating questions that can accompany other types of experiments (quantitative or qualitative).

In the first phase of our work we asked you to provide a few terms that you consider to be usable in an aesthetic rating. In addition to terms provided by experts like you, we have also assessed the literature and come up with a final list of 37 terms; narrowed down from a list of > 200 terms. An important second phase in scale development is to ask experts to rate the appropriateness of the terms we collected. As such, we would much appreciate it if you could spend around 3-4 minutes of your time to fill out our second survey. We hope that at least as a small reward seeing the list of terms may already be useful or inspiring to you.

To participate, please access the survey here: [survey link]

We thank you a lot in advance and would be happy to share the results of our work with you if you are interested! Just let us know.

Best regards, Tingying He, Petra Isenberg, Raimund Dachselt, and Tobias Isenberg

#### Survey for reviewing terms (25 responses)

The aesthetic pleasure of visualization is the pleasure people derive from looking at a visualization for its own sake, as a source of immediate experiential pleasure in itself, and not essentially for its utility in producing insight or knowledge gain or something else that is either useful or pleasurable.

The table below includes terms that have been suggested or used in the literature by visualization experts like you for studying the aesthetic pleasure of a visualization. Imagine that these terms would later be used in a rating scale that asks participants to select to what extent a visualization is ...[term].

Below we would like you to rate these different terms according to how relevant you consider them for actually judging the aesthetic pleasure of a visualization. Please note that we only care about aesthetic pleasure in terms of what a visualization looks like and not how well people can comprehend the data that it shows.

#### How relevant do you think the following terms are for judging or describing the aesthetic pleasure of a visualization?

	1 = not at all relevant	2	3	4	5 = very relevant
sophisticated					
beautiful					
appealing					
likable					
cluttered					
enjoyable					
tasteful					
modern					
aesthetic					
clean					
color-harmonious					
boring					
satisfying					
delightful					
entertaining					
exciting					
attractive					
good					
interesting					

#### Step 2: Term Filtering

# 31 Terms

aesthetic	emotion	cognitive	other
appealing artistic attractive balanced beautiful clean cluttered color-harmonious creative elegant harmonious inviting lovely nice organized pretty tasteful well-designed	appealing delightful engaging enjoyable exciting fascinating interesting likable motivating pleasing provoking satisfying	cluttered	professional sophisticated

#### Step 3: Exploratory Phase

# **Crowdsourced Experiment**

- 1001 participants
- **15** data representations

Each participant rated 3 representations



	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
motivating							
provoking							
organized							
engaging							
creative							
clean							
aesthetic							
beautiful							
pretty							
pleasing							
fascinating							
elegant							
	Strongly		Slightly		Slightly		Strongly

Previous

#### Exploratory experiment screenshot

Image from Liu et al., 2013 (https://doi.org/10.1109/TVCG.2008.166) © IEEE, used with permission.

Next

#### 15 data representations we used in our exploratory experiment



#### **2D** vs. 3D



JURA55IC

#### 2D vs. **3D**



#### Black background vs. White background



#### Black background vs. White background



#### Abstract vs. Physical content



#### Abstract vs. Physical content



#### Handcrafted (appearance) vs. (clearly) Computer-generated



#### Handcrafted (appearance) vs. (clearly) Computer-generated



#### Black and white vs. Colorful



#### Black and white vs. Colorful



Step 3: Exploratory Phase

# **Exploratory Factor Analysis**

Potential factor structure of our scale: 1 factor



Scree plot for Image 1 (3D surface glyphs), see our paper for details

## **Exploratory Factor Analysis**

terms / image	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
likable	0.91	0.79	0.88	0.87	0.86	0.84	0.90	0.88	0.84	0.86	0.85	0.89	0.87	0.87	0.89	0.87
pleasing	0.85	0.80	0.84	0.88	0.89	0.87	0.90	0.84	0.80	0.88	0.87	0.88	0.87	0.84	0.88	0.86
enjoyable	0.87	0.78	0.83	0.86	0.86	0.84	0.88	0.87	0.84	0.87	0.85	0.88	0.83	0.85	0.89	0.86
appealing	0.85	0.80	0.80	0.84	0.87	0.83	0.88	0.85	0.85	0.88	0.85	0.88	0.88	0.83	0.90	0.85
nice	0.90	0.81	0.81	0.82	0.87	0.83	0.87	0.87	0.81	0.85	0.84	0.82	0.89	0.82	0.89	0.85
attractive	0.84	0.78	0.81	0.81	0.86	0.87	0.89	0.84	0.84	0.86	0.85	0.87	0.86	0.84	0.85	0.84
delightful	0.86	0.74	0.78	0.85	0.83	0.81	0.89	0.82	0.79	0.82	0.86	0.88	0.89	0.84	0.88	0.83
satisfying	0.77	0.73	0.77	0.83	0.85	0.80	0.90	0.80	0.82	0.85	0.86	0.87	0.85	0.81	0.84	0.83
pretty	0.85	0.76	0.77	0.78	0.81	0.81	0.88	0.79	0.76	0.80	0.84	0.85	0.83	0.86	0.85	0.82
beautiful	0.84	0.77	0.76	0.79	0.84	0.78	0.87	0.81	0.76	0.82	0.85	0.85	0.78	0.82	0.84	0.81
lovely	0.85	0.75	0.78	0.82	0.80	0.77	0.83	0.81	0.74	0.81	0.86	0.86	0.83	0.79	0.83	0.81
inviting	0.83	0.74	0.71	0.73	0.82	0.80	0.84	0.85	0.78	0.78	0.83	0.78	0.84	0.76	0.83	0.79
engaging	0.79	0.70	U./D	U./4	U./ŏ	U./ŏ	U.ŏZ	U.ŏ3	U./4	U./O	0.19	U.//	U.ŏU	0./3	U.ŏU	U.//
tasteful	0.78	0.64	0.68	0.72	0.77	0.78	0.80	0.81	0.81	0.80	0.82	0.76	0.81	0.77	0.83	0.77
exciting	0.79	0.66	0.72	0.76	0.81	0.76	0.81	0.77	0.70	0.77	0.82	0.77	0.79	0.75	0.79	0.77
motivating	0.74	0.65	0.71	0.77	0.83	0.78	0.84	0.75	0.75	0.77	0.78	0.71	0.83	0.76	0.77	0.76
elegant	0.83	0.76	0.71	0.78	0.74	0.68	0.83	0.69	0.71	0.84	0.76	0.80	0.78	0.74	0.80	0.76
harmonious	0.79	0.69	0.76	0.75	0.82	0.74	0.74	0.74	0.69	0.80	0.77	0.80	0.76	0.75	0.81	0.76
well designed	0.76	0.71	0.67	0.77	0.81	0.73	0.69	0.71	0.73	0.74	0.76	0.81	0.81	0.66	0.76	0.74
fascinating	0.68	0.64	0.73	0.77	0.70	0.72	0.80	0.71	0.72	0.66	0.73	0.77	0.76	0.70	0.71	0.72
interesting	0.70	0.70	0.71	0.74	0.76	0.71	0.73	0.74	0.61	0.64	0.70	0.73	0.74	0.59	0.74	0.70
balanced	0.69	0.63	0.61	0.73	0.71	0.69	0.59	0.70	0.65	0.77	0.74	0.66	0.68	0.71	0.74	0.69
clean	0.73	0.70	0.71	0.64	0.70	0.60	0.66	0.70	0.60	0.68	0.71	0.71	0.63	0.73	0.67	0.68
sophisticated	0.68	0.63	0.62	0.63	0.61	0.62	0.73	0.65	0.66	0.63	0.63	0.75	0.71	0.71	0.71	0.66
organized	0.59	0.61	0.62	0.74	0.67	0.59	0.55	0.60	0.59	0.66	0.64	0.66	0.65	0.62	0.65	0.63
creative	0.53	0.49	0.55	0.60	0.67	0.62	0.66	0.70	0.62	0.68	0.65	0.64	0.58	0.54	0.65	0.61
artistic	0.52	0.49	0.51	0.59	0.66	0.63	0.69	0.61	0.56	0.66	0.64	0.69	0.55	0.58	0.67	0.60
professional	0.63	0.67	0.52	0.61	0.62	0.53	0.60	0.46	0.50	0.61	0.52	0.67	0.67	0.62	0.60	0.59
color harmonious	0.65	0.59	0.63	0.63	0.64	0.63	0.48	0.55	0.43	0.62	0.51	0.62	0.43	0.64	0.64	0.58
provoking	0.17	0.20	0.22	0.28	0.28	0.33	0.19	0.37	0.32	0.27	0.40	0.32	0.22	0.22	0.35	0.28
cluttered	0.30	-0.33	0.03	0.15	0.39	0.18	0.27	0.34	0.41	0.45	0.21	-0.05	0.12	0.05	0.24	0.18



#### Retained **12 terms** with a factor loading > 0.7 for all 15 images

Factor loadings for all 31 terms and 15 images

# Reliability: Cronbach's Alpha

Alpha > 0.7 : Reliable

[Boateng et al., 2018]

	- • • • •	i (;	lpha 💻	7 0.91	.0				3-	item s	scale								
	Enjoyable	terme / Image	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	ury	
	Likable	enjoyable-likable-pleasing	0.92	0.86	0.89	0.91	0.91	0.90	0.94	0.92	0.88	0.92	0.91	0.93	0.91	0.92	0.93	0.91	0.9
	Pleasing	enjoyable-IIKable-nice	0.93	0.87	0.90	0.90	0.91	0.89	0.93	0.92	0.88	0.91	0.91	0.92	0.91	0.92	0.93	0.91	
		likable-nice-pleasing	0.93	0.87	0.88	0.90	0.92	0.90	0.93	0.91	0.86	0.91	0.91	0.92	0.91	0.91	0.92	0.91	
	Enjoyable								4-	item s	scale								
	Likable	enjoyable-likable-pleasing	0.94	0.90	0.91	0.92	0.93	0.92	0.95	0.94	0.90	0.93	0.93	0.94	0.93	0.93	0.95	0.93	0.9
	Pleasing	enjoyable likeble appealing	0.94	0.89	0.91	0.93	0.93	0.92	0.95	0.94	0.91	0.94	0.92	0.94	0.93	0.93	0.94	0.93	-
	Nice	enjoyable-likable-appealing -nice	0.94	0.90	0.91	0.92	0.93	0.92	0.95	0.94	0.91	0.93	0.92	0.94	0.93	0.93	0.95	0.93	
1									5-	item :	scale								
	Enjoyable	enjoyable-likable-nice -pleasing-appealing	0.95	0.92	0.92	0.94	0.94	0.94	0.96	0.95	0.92	0.94	0.94	0.95	0.95	0.94	0.96	0.94	0.9
	Likable	appealing attractive	0.04	0.01	0.02	0.04	0.04	0.02	0.06	0.04	0.02	0.05	0.04	0.05	0.04	0.04	0.05	0.04	
	Pleasing	-enjoyable-likable-pleasing	0.94	0.91	0.92	0.94	0.94	0.93	0.90	0.94	0.92	0.95	0.94	0.95	0.94	0.94	0.95	0.94	
	Nice	attractive-enjoyable-likable -nice-pleasing	0.95	0.91	0.92	0.93	0.94	0.94	0.96	0.94	0.92	0.94	0.94	0.95	0.94	0.94	0.95	0.94	
	Annealing																		

Cronbach's alpha for each image on the most reliable 3-, 4-, and 5-item subsets of the remaining 12 terms with factor loading > 0.7.

## BeauVis Scale

#### To what extent do you agree that this visual representation is ... ?



BeauVis scale in its recommended version

#### Step 4: Validation Phase

# **Crowdsourced Experiment**

- 201 participants
- 3 data representations

To what extent do you agree or disagree with the following statement:



	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
likable							
symmetric							
clean							
pleasant							
appealing							
pleasing							
clear							
aesthetic							
nice							
enjoyable							

Previous

Confirmatory experiment screenshot Terms from the BeauVis scale and Lavie and Tractinsky's scale

Image from Cawthon and Vande Moere, 2007 (https://doi.org/10.1109/IV.2007.147); © IEEE, used with permission.

Next

#### 3 data representations we used in our confirmatory experiment

Ranking for aesthetic pleasure in the previous study. [Cawthon & Vande Moere, 2007]







SunBurst

StarTree

Most beautiful

BeamTree



Images from Cawthon and Vande Moere, 2007 (https://doi.org/10.1109/IV.2007.147); © IEEE, used with permission.

# BeauVis Replicated the Aesthetic Ranking [Cawthon & Vande Moere, 2007]



Images from Cawthon and Vande Moere, 2007 (https://doi.org/10.1109/IV.2007.147); © IEEE, used with permission.

# Confirmatory Factor Analysis

	SunBurst	StarTree	BeamTree
<i>p</i> -value ( $\chi^2$ )	0.290	0.222	0.016
TLI	0.998	0.996	0.982
CFI	0.999	0.998	0.991
SRMR	0.009	0.011	0.014
RMSEA	0.034	0.045	0.095

Goodness of fit indices

Item	Factor Loading							
Item	SunBurst	StarTree	BeamTree					
enjoyable	0.893	0.878	0.911					
likable	0.914	0.925	0.874					
pleasing	0.889	0.895	0.893					
nice	0.845	0.877	0.888					
appealing	0.910	0.842	0.889					

Standardized factor loading for 5 items

# Reliability

	SunBurst	StarTree	BeamTree
Cronbach's Alpha	0.95	0.946	0.95

Cronbach's alpha for each visualization

# Validity

	SunBurst	StarTree	BeamTree
Classic Aesthetic	0.84	0.88	0.87
Age	0.07	0.12	0.14

Pearson correlation

# Usage of the BeauVis Scale

Rapidly compare the aesthetic pleasure of different visual data representations.



Recommended form of using the BeauVis scale

# Usage of the BeauVis Scale

BeauVis Scale

+

To what extent do you agree that this visual representation is ?										
stro	ngly disagr	ee				ş	trongly agree			
enjoyable										
likable	0-	-0-	-0-	-0-	-0-	-0-				
pleasing										
nice	0-	-0-	-0-	-0-	-0-					
appealing										

#### Other Research Methods





Images from unDraw (https://undraw.co/); ©2022 · Katerina Limpitsouni, used with permission.



# BeauVis: A Validated Scale for Measuring the Aesthetic Pleasure of Visual Representations

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