Aesthetics in Information Visualization

Hauptseminar “Information Visualization - Wintersemester 2008/2009"

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Agenda

- Definitions
- Aesthetic Measures
- Aesthetic Visualization Approaches
- Aesthetics and User Experience
- Outlook

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Definitions

Visualization

“Binding (or mapping) of data to representations that can be perceived.”
(Foley and Ribarsky, 1994)

- Scientific Visualization - “visual display of spatial data”
- Information Visualization - “visual display of nonspatial data”
- Visual Analytics - “analytical reasoning facilitated by visual interfaces”

(Rhyne, 2008)

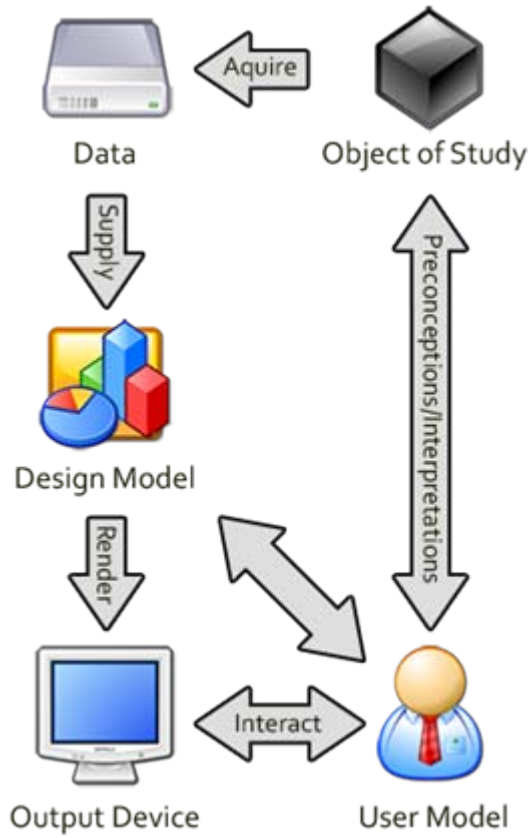

Figure 1: Visualization Process as described by Tory and Möller.

Definitions

Aesthetics

- Philosophical study of art and beauty
- Different academic approaches
- Aesthetics can be found in many dimensions

"An anesthetic is used to dull or deaden, causing sleepiness and numbness. In contrast, aesthetic is seen as something that enlivens or invigorates both body and mind, awakening the senses." (Cawthon and Moere, 2006)

Figure 2: Aphrodite of Melos (Venus de Milo). (Shaw, 2004)

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Aesthetic Measures

Birkhoff's Aesthetic Measure

Observer

1 **Effort**

Related to the complexity (C) of the object.

2 **Feeling**

Related to the aesthetic value (M).

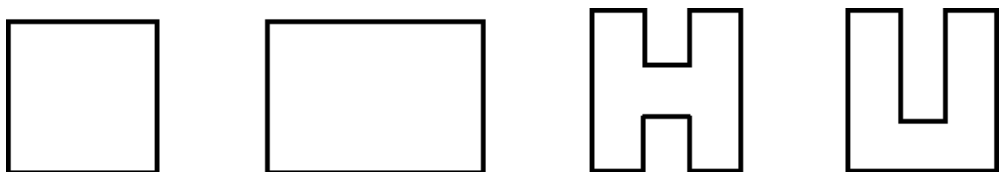
3 **Knowledge**

Verification of the order (O) within the object

Object

➔ Birkhoff defines the aesthetic measure:

$$M = \frac{O}{C}$$



M=1.50 M=1.25 M=0.50 M=0.14

Figure 3: Birkhoff's aesthetic measure applied to polygons. (Burns, 2006)

Aesthetic Measures

Klinger and Salingaros' Pattern Measure

Based on the descriptors:

- Number of different elements (T)
- Number of symmetries (H)

➔ Derived measures (L, C) are defined as follows:

$$L = TH$$
$$C = T(H_{max} - H)$$

L = 6.1
C = 8.9

L = 4.8
C = 12.0

Figure 5: Klinger and Salingaros' Pattern Measure.

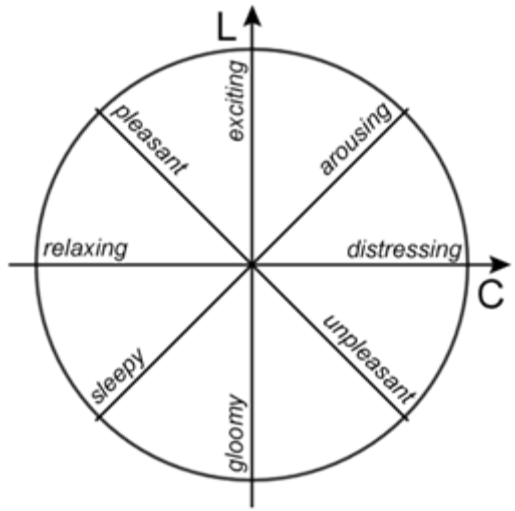


Figure 4: Psychological responses to the derived measures L and C.

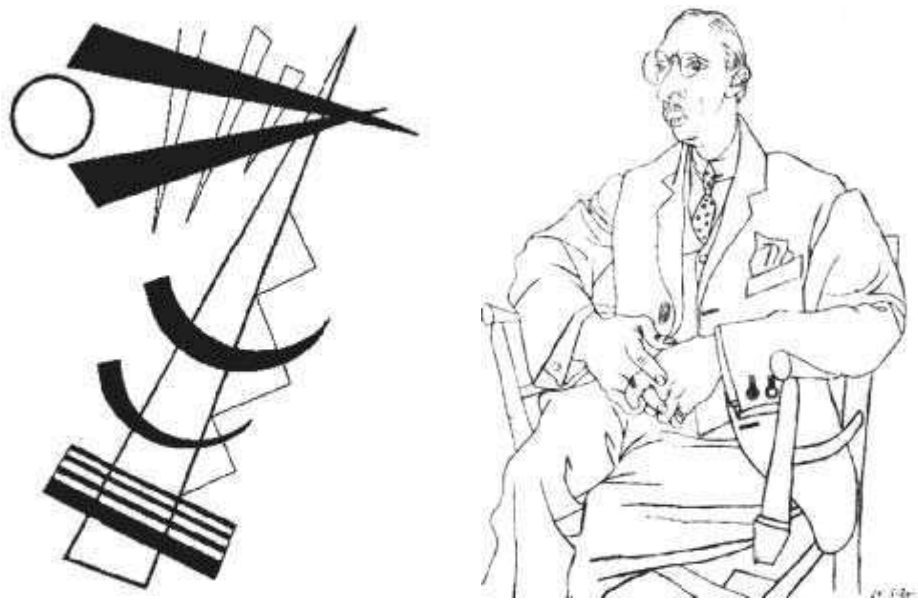
Aesthetic Measures

Hereditary Combinatorial Entropy

- Image represented as finite set of curves
- Combinatorial entropy is defined as the expected number of intersections of a random line with the image

$$H_c(D) = Ex(i(L, D))$$

- An aesthetically pleasing design has a combinatorial entropy in each of its meaningful parts proportional to the global combinatorial entropy



H_C=6.32 H_C=14.09

Figure 6: Combinatorial Entropy of Kandinsky and Picasso drawings. (Nesetril, 2005)

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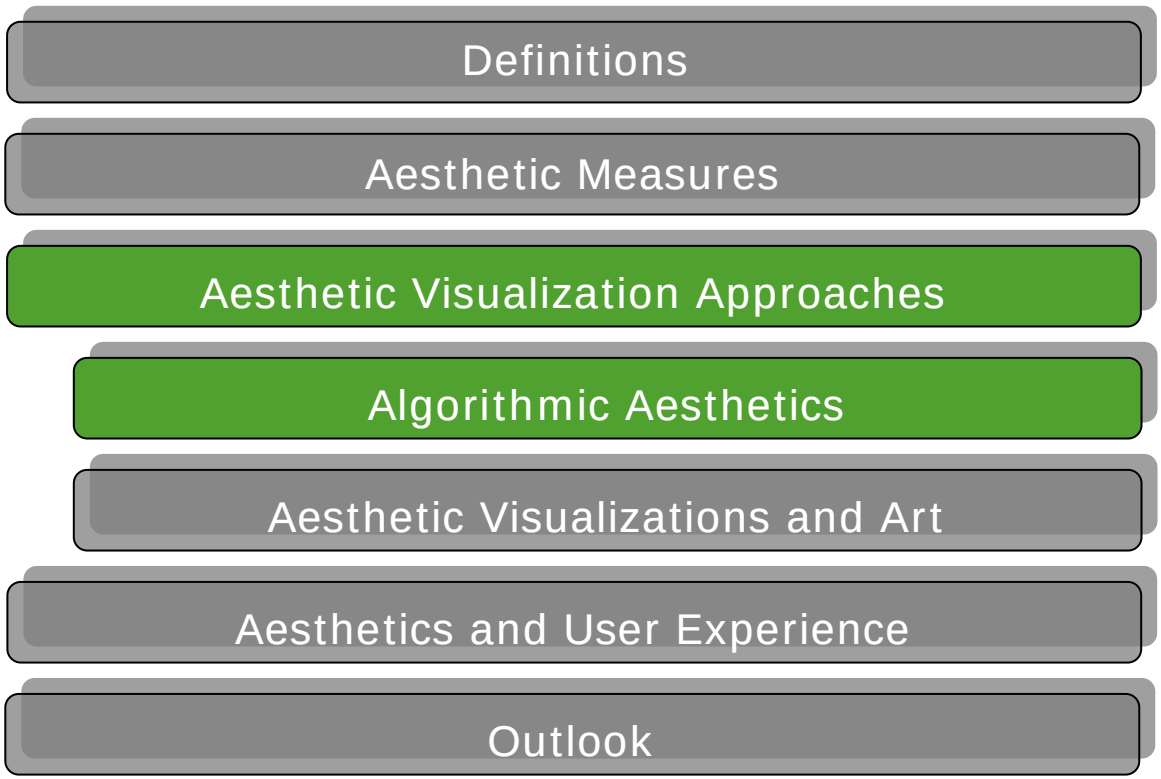
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Algorithmic Aesthetics
Aesthetic Visualizations and Art
Aesthetics and User Experience
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Aesthetic Visualization Approaches

Algorithmic Aesthetics - Exact Aesthetics

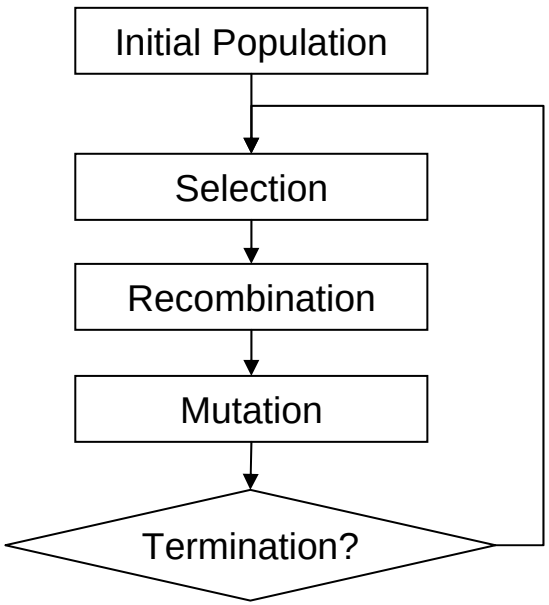
- Reconstruction of methods of design and criticism on algorithmic basis
- Integration of the computer into the process of artistic creation and aesthetic evaluation

Figure 7: A pattern generated by the Arthur application.
(Staudek and Machala, 2002)

Aesthetic Visualization Approaches

Algorithmic Aesthetics - Genetic Algorithms

- Inspired by evolutionary processes in nature
- Dynamic and adaptive algorithms with a wide range of applications



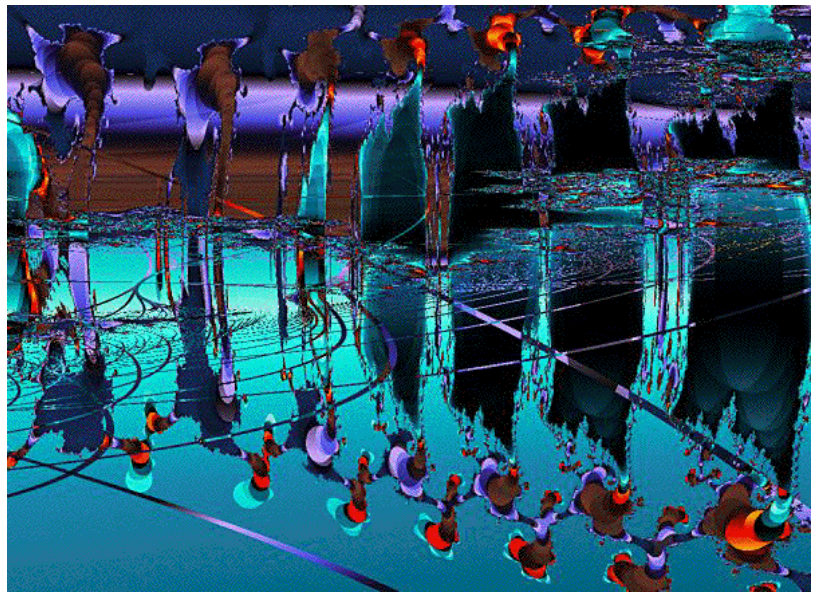


Figure 8: „Skaters“ by Steven Rooke. (Judelman, 2004)

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Aesthetic Visualization Approaches

Aesthetic Visualizations and Art – Impressionist Art

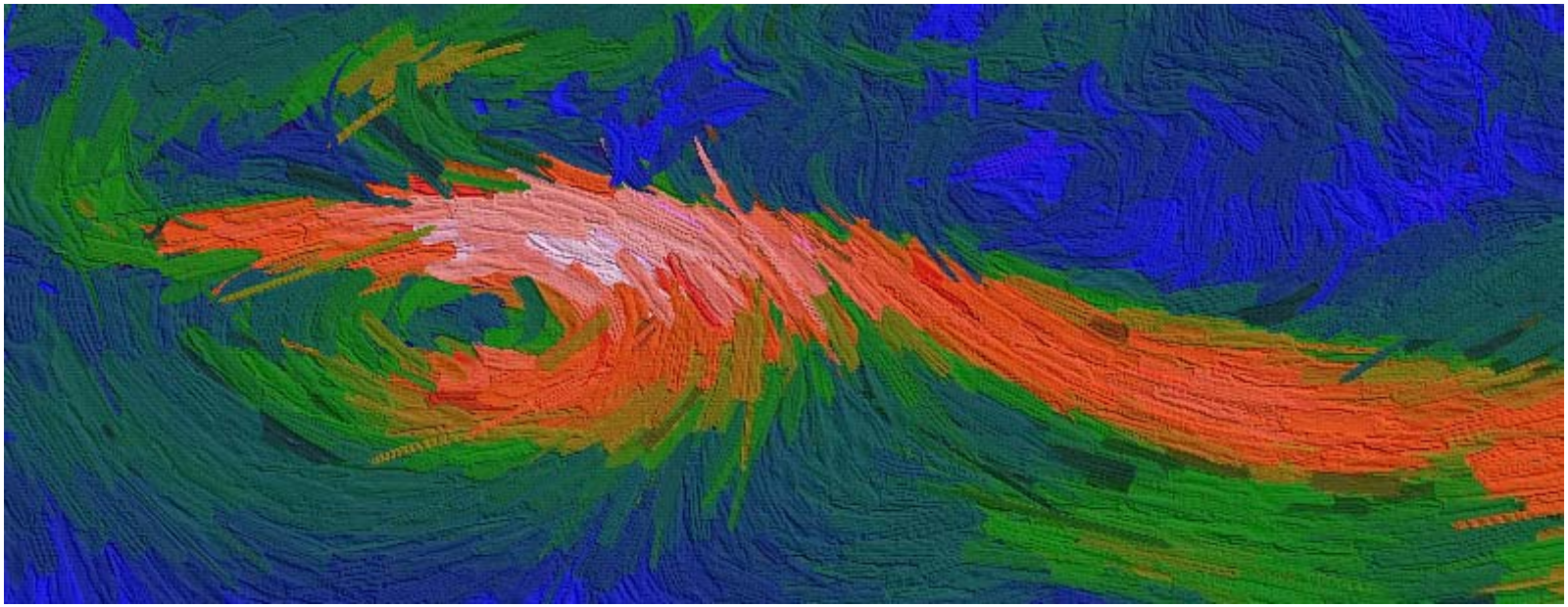

Figure 9: Visualization of a simulated supernova collapse. (Tateosian et al., 2007)

Aesthetic Visualization Approaches

Aesthetic Visualizations and Art – Abstract Art

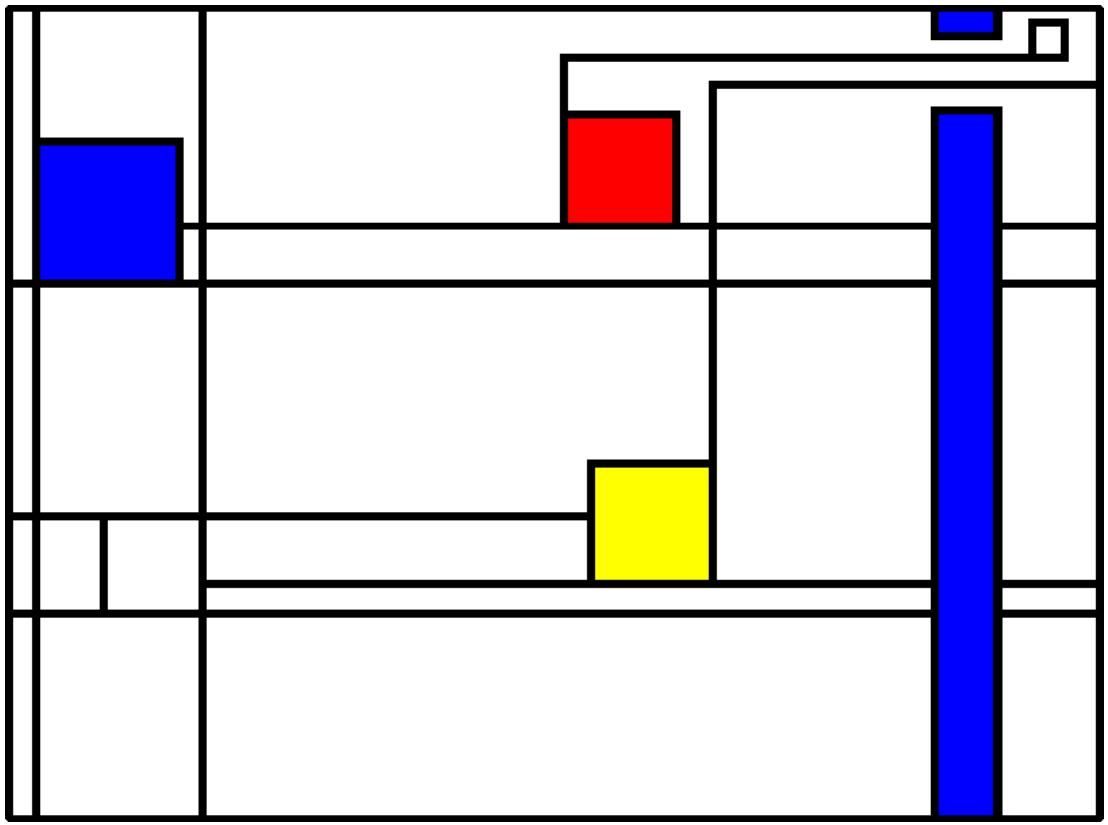

Figure 10: Visualization of bus traffic. (Skog et al., 2003)

Aesthetic Visualization Approaches

Aesthetic Visualizations and Art – Pop and Op Art

Figure 11: Visualization of a timer.
(Holmquist and Skog, 2003)

Figure 12: „The Top Grossing Film of All Time“ by Jason Salavon.
(Viegas and Wattenberg, 2007)

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Aesthetics and User Experience

Why should we consider aesthetics?

- An effective visualization should attract and hold a viewers attention
- Aesthetics can facilitate a greater mental immersion into the underlying data
- Positive affect is likely to improve decision making and creativity

> *"It is only through our emotions do we unravel problems, as the human emotional system is intertwined with our cognitive abilities." (Norman, 2004)*

Aesthetics and User Experience

Empirical evidence of aesthetic effects

- Conventional metrics of participant task timing and the quantified fulfillment of goals do not capture all the aspects of user experience
- Empirical studies show strong correlation between the perceived aesthetics and the perceived usability of the system (Tractinsky et al., 2000)
- Empirical studies show that users approach aesthetic visualizations more thoroughly and with greater patience (Cawthon and Moere, 2007)

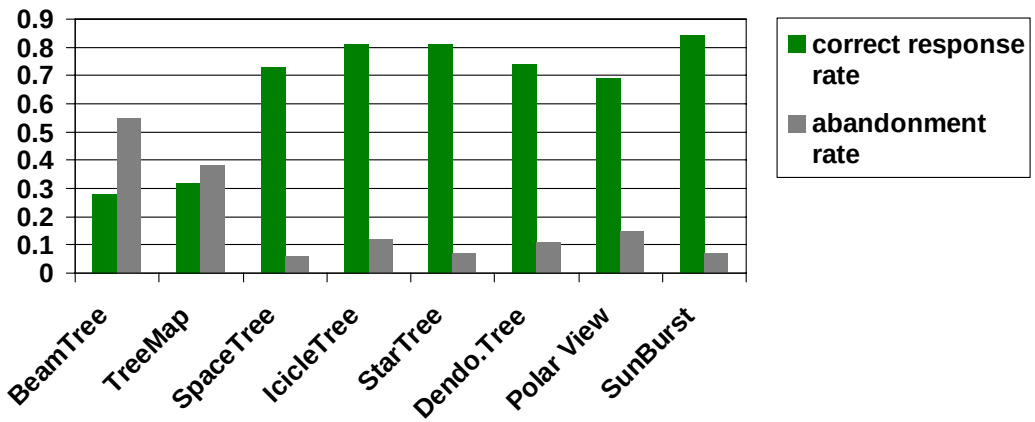

Figure 13: Results of a study by Cawthon and Moere.
Visualizations ordered by ascending aesthetic ranking.

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Outlook

Future work could include:

- Testing different measures with a common set of visualizations
- Combination of different measures into one metric
- Incorporate complexity of the underlying data into aesthetic measures
- Verification with a survey of a representative group of users
- Further exploration of art styles

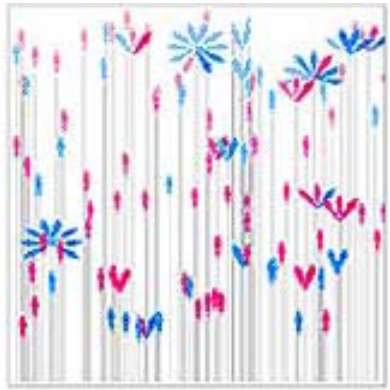

Figure 14: Chat activity.
(Cawthon and Moere, 2006)

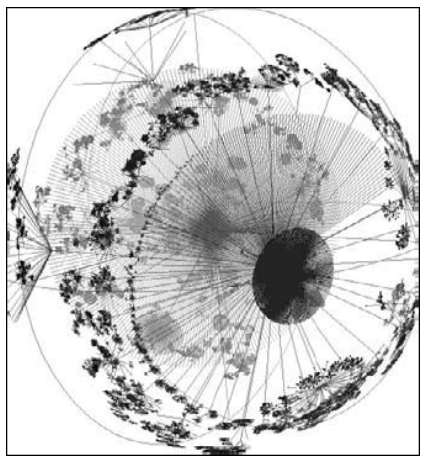

Figure 15: Internet topology.
(Wyeld, 2005)

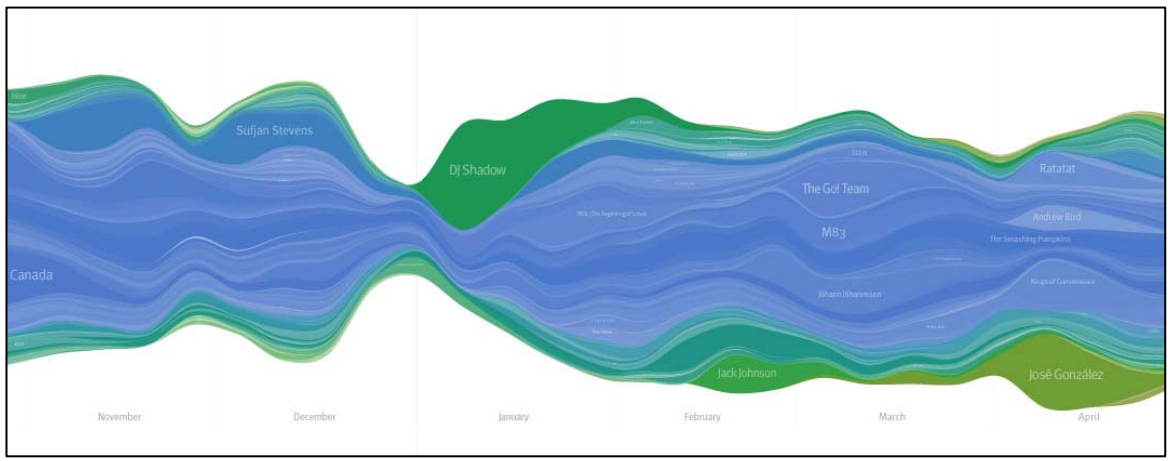

Figure 16: Last.fm listening history.
(Byron, 2006)

Thank you for your attention.

Questions?

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Backup

Birkhoff's Aesthetic Measure

$$M = \frac{O}{C} = \frac{V + E + R + HV - F}{C}$$

- The complexity *C* of a polygon is defined as the number of distinct straight lines containing at least one side of the polygon.
- *V* is a measure of vertical symmetry. *V* is 1 or 0 according as the polygon is or is not symmetric about a vertical axis.
- *E* is a measure of equilibrium. *E* is 1 whenever *V* is 1. *E* is also 1 if the centre of area *K* is situated directly above a point *D* within a horizontal line segment *AB* supporting the polygon from below in such wise that the lengths *AD* and *BD* are both more than 1/6 of the total horizontal breadth of the polygon. *E* is 0 in any other case when *K* lies above a point of *AB*, even if *A* and *B* coincide. *E* is -1 in the remaining cases.
- *R* is a measure of rotational symmetry. *R* is the smaller of the numbers *q*/2 and 3 (where 360° /*q* is the least angle of rotation which rotates the polygon into itself) in the case of rotational symmetry, provided that the polygon has vertical symmetry or else that the minimum enclosing convex polygon has vertical symmetry and that the niches of the given polygon do not abut on the vertices of the enclosing polygon. *R* is 1 in any other case when *q* is even (i.e., if there is a central symmetry). *R* is 0 in the remaining cases.
- *HV* is a measure of the relation of the polygon to a horizontal-vertical network. *HV* is 2 only when the sides of the polygon lie upon the lines of a uniform horizontal-vertical network, and occupy all the lines of a rectangular portion of the network. *HV* is 1 if these conditions are satisfied, with one or both of the following exceptions: one line and the others of this type may fall along diagonals of the rectangular portion or of adjoining rectangles of the network; one vertical line and one horizontal line of the portion, and the others of the same type, may not be occupied by a side. At least two vertical and two horizontal lines must be filled by the sides however. *HV* is also 1 when the sides of the polygon lie upon the lines of a uniform network of two sets of parallel lines equally inclined to the vertical, and occupy all the lines of a diamond-shaped portion of the network, with the following possible exceptions: at most one line and the others of the same type may fall along diagonals of the diamond-shaped portion or of the adjoining diamonds of the network; one line of the diamond-shaped portion and the others of its type may not be occupied by a side. At least two lines of either set of parallel lines in the network must, however, be occupied by the sides. *HV* is 0 in all other cases.
- F is a general negative factor. F is 0 if the following conditions are satisfied: the minimum distance from any vertex to any other vertex or side or between parallel sides is at least 1/10 the maximum distance between points of the polygon; the angle between two non-parallel sides is not less than 20° ; no shift of the vertices by less than 1/10 of the distance to the nearest vertex can introduce a new element or order V, R, or HV; there is no unsupported reentrant side; there is at most one type of niche and two types of directions, provided that vertical and horizontal directions are counted together as one; V and R are not both 0. F is 1 if these conditions are fulfilled with one exception and one only. F is 2 in all other cases.

(Ngo et al., 2000)