Design Elements and the Perception of Information Structure

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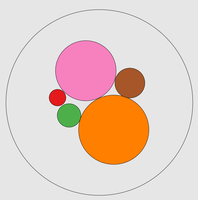
Abstract

Can background structural elements of information visualization, even minor and seemingly meaningless design properties, contribute to the perception of the data's semantic properties? By altering simple design elements of five types of basic charts, we significantly affected participants' subjective ratings of visualized data.

Our participants rated imaginary companies based on simple charts of departmental spending. Reactions to a chart often reflected its implied physical properties, which were sometimes metaphorically extended to semantic judgements of the data.

“Seems like it might just roll away!”

"The square has everything connected, with no room to move around."

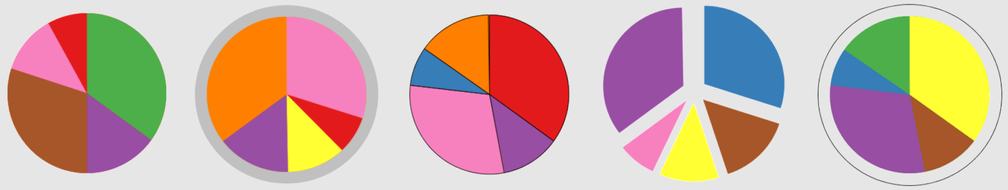


"It has limits but has more flexibility for people to work within their responsibility.”

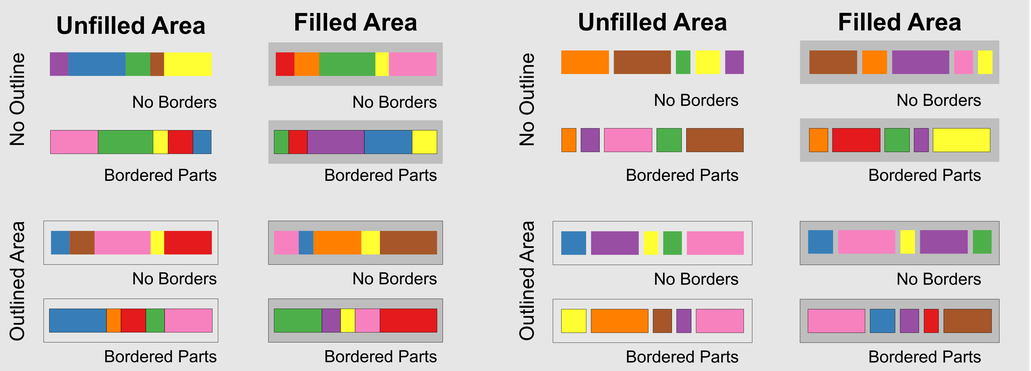
"Like an advertising agency where people work on one project and everyone contributes ideas and they are melded into one whole."

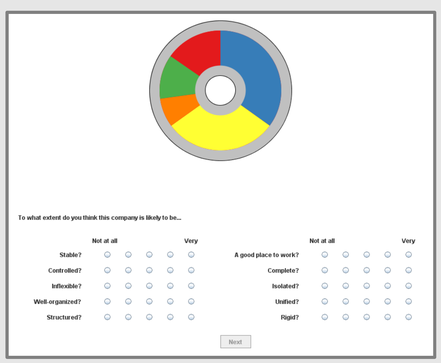
Design Elements

We chose four design elements which we hypothesize to carry structural information about data: **filled area**, **bordered parts**, **joined/separate parts**, and **outlined area**.



We applied these design elements to five different simple chart types. Each chart type comes in sixteen configurations, demonstrated below on stacked bars.





Experiment

Forty-two participants from Amazon's Mechanical Turk each saw 20 charts with different design configurations in random order and were asked to rate each visualized “company” on a scale of 1 to 5 for ten semantic variables: *good place to work, complete, controlled, inflexible, isolated, rigid, stable, structured, unified*, and *well-organized*.

Results

All of the design elements except for outlined area produced significant differences in at least one of the ten semantic variables we tested. We also found a number of significant interactions among the four design elements. We found few significant interactions among chart type and design, suggesting that these design effects are largely constant across the visualization types we chose.

Factor	Group	Stable	Complete	Controlled	Inflexible	Rigid	Structured	Isolated	Unified	Well Organized	Good Place to Work
Filled Area	yes	3.06	3.00	2.93	**2.64**	**2.61**	3.20	2.66	3.00	3.04	2.97
	no	3.03	3.03	3.08	**2.88 (+)**	**2.88 (+)**	3.17	2.74	2.88	3.15	3.01
Bordered Parts	yes	**2.93**	**2.91**	**3.12 (+)**	**2.88 (+)**	2.82	3.21	2.74	2.89	3.08	2.96
	no	**3.14 (+)**	**3.10 (+)**	**2.92**	**2.66**	2.69	3.16	2.67	2.98	3.11	3.02
Joined Parts	yes	**3.14 (+)**	**3.20 (+)**	**3.14 (+)**	2.83	**2.90 (+)**	**3.31 (+)**	2.62	**3.11 (+)**	**3.22 (+)**	3.05
	no	**2.95**	**2.83**	**2.88**	2.69	**2.59**	**3.05**	2.78	**2.78**	**2.97**	2.93
Outlined Area	yes	3.03	3.04	3.00	2.75	2.75	3.18	2.71	2.92	3.07	2.98
	no	3.06	2.99	3.01	2.78	2.75	3.19	2.69	2.97	3.12	3.00

Mean semantic ratings (on a scale of 1-5) across all design elements. Differences which are significant at a $p < .01$ level are in boldface and the higher value is marked with a (+).

Chart Type	Stable	Complete	Controlled	Inflexible	Rigid	Structured	Isolated	Unified	Well Organized	Good Place to Work
waffle	3.23	3.14	**3.24 (+)**	**3.05 (+)**	**3.06 (+)**	3.45	2.77	3.10	**3.36 (+)**	2.96
bars	3.11	3.12	**3.26 (+)**	2.93	**2.98 (+)**	3.37	2.63	2.89	3.21	2.95
pie	3.17	3.16	3.07	2.63	2.73	3.26	2.72	3.05	3.18	3.08
donut	3.11	3.02	**2.86 (-)**	2.74	**2.60 (-)**	3.17	2.69	3.01	3.04	3.03
bubble	**2.61 (-)**	**2.64 (-)**	**2.61 (-)**	**2.45 (-)**	**2.36 (-)**	**2.66 (-)**	2.70	**2.68 (-)**	**2.69 (-)**	2.94

We also found semantic effects of chart type. A Tukey HSD post-hoc test was used for pairwise comparisons of the five charts. Values significantly higher (at a $p < .05$ level) than at least two other categories are marked with a (+) and values significantly lower than at least two categories are marked with a (-).

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