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# Interacting with more than One Chart: What is It All about?

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**Abstract.** Visual objects made of multiple views, e.g., dashboards and small multiples, are taking the scene in information communication and visual patterns design, but still vague are the studies that try to abstract away from characterizing them at the level of their single charts, and rather focus on their structural characteristics and the resulting interactions with their multi-view ensemble seen as a whole. In this paper, we are proposing this unified view through a multi-dimensional wheel, on the strand of Cairo’s wheel made for infographics, devised for the identification, the analysis, and the evaluation of design patterns for multiple views.

**Keywords:** Visualization Techniques · Tools for Design, Modelling, Evaluation · Multiple Coordinated Views · Dashboards · Small Multiples.

## 1 What are Dashboards and Multiple Views from an Interactionist Point of View

This paper moves from the current definitions and characterizations of MCVs such as dashboards [2] and small multiples [5] to provide a formal “middle layer” between the conceptual vagueness of their definition and the concrete details of their instantiation [3, 4], so as to see whether new interaction challenges may emerge, be evaluated and designed starting from an *holistic* perspective.

In particular, we argue that the main kind of interaction with visual objects like dashboards seems to roughly correspond to a “tree-like graph visit”: starting from the root (overview), and going deep into details. According to this formal structure, the interaction style of individuals with a dashboard may be defined as *recursive*.

To exemplify this kind of interactional recursive behavior, Figure 1a depicts a recursive navigational style, where a person makes an operation  $o$  (e.g., a selection or a filter) on a dashboard  $d$ , through an interface operational functionality  $f_o$  until a bottom node (a leaf in the graph style metaphor) is not reached, which is still a meaningful level. A meaningful level of detail may be formally defined on hierarchical family of partitions  $P$  of a dataset [6], e.g., a dataset subset according to some other selection/filtering criteria, one category of a categorical

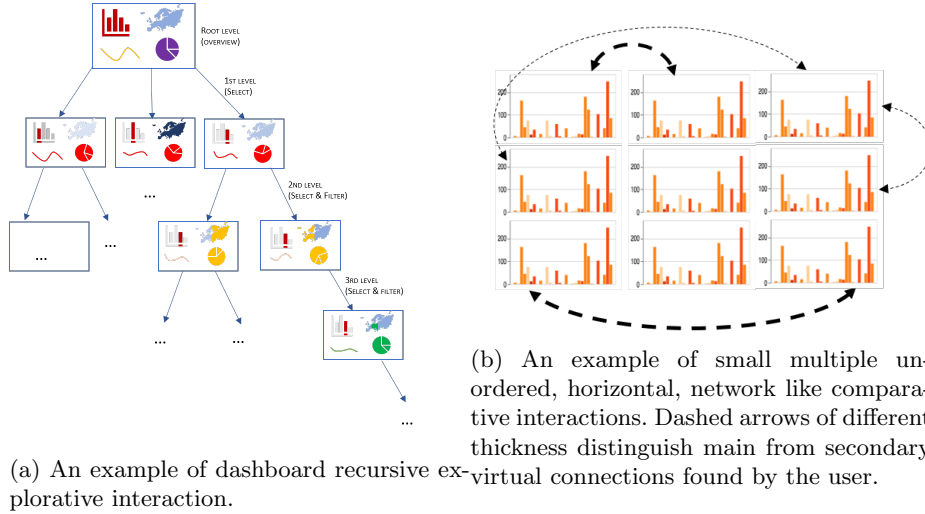


Fig. 1: Dual nature of multiple views interactions.

dataset, one data point, and so on, which can still be displayed at the dashboard (whole)-view and where this view can be considered still meaningful. Formally:

$$\bigcup a_i, \bigcup a_j \in P, o \in O, d \in D, f_o : D_{a_i} \rightarrow D_{a_j}, \dots, f_o(f_o(d_a)) \quad (1)$$

On the opposite, interacting with small multiples roughly corresponds to navigating in a “network-like graphs”, where charts (nodes) are of the same kind (when not the same “node” with a small variation, all the rest being equal) and the eyes go back and forth from one “node” to another one, in what can be called an *iterative* navigation style, until a meaningful relational pattern is reached in the eye of the user. Formally, a small multiple can be seen as a graph structure  $G = (C, E, f_o)$ , with charts  $c$  as nodes ( $c \in C$ ), meaningful patterns as virtual edges ( $e \in E$ ), and an operational goal  $f_o$  executed by a user iteratively to “visually connect” two charts by a meaningful virtual edge:

$$E = \{(c_1, c_2) \in C \mid c_1 \neq c_2\} \iff \exists f_o : C \rightarrow C \quad (2)$$

## 2 The multiple views wheel: a bird’s view

What are the interaction properties that are recognizable for these two orthogonal interaction styles? We identify eight well known interaction dimensions that were applied partly to single charts and are also applicable to multiple views and viceversa. Starting from the previous work, we provide a formal definition, at the level of the multiple views visual construct, to which the structure of our wheel may be referred to.

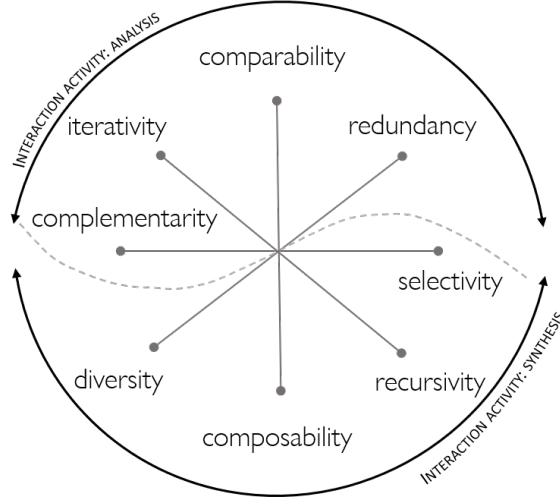


Fig. 2: The multi-chart wheel, inspired by Alberto Cairo’s wheel on Infographics design dimensions [1]. This wheel depicts the interaction dimensions mainly with small multiples (upper emicycle) and mainly with dashboards (lower emicycle).

Given  $P$  as a dataset partition family and  $F, G, Z$  as visual mapping functions of a dataset partition into a chart, each dimension of the wheel, at the multiple views level, may be formally characterized as follows:

*Iterativity*: for any pair of a dataset partition elements,  $\forall a_i, a_j \in P_z, a_i \neq a_j$ , there may exist a relationship  $\exists R : F \times F$ , virtually connecting each pair of charts  $F(a_i), F(a_j)$ , from repeated observations by a user. For example, in a small multiples view we iterate the interaction on the same chart on each category of a categorical dataset, by repeatedly observing and finding connections.

*Comparability*: for any pair of a dataset partition elements,  $\forall a_i, a_j \in P_z, a_i \neq a_j$ , there exists a visual mapping of the same kind mapping each partition element to the same kind of chart,  $F(a_i) \wedge F(a_j)$ . This configuration allows the comparability of each pair of elements of a dataset partition during interaction.

*Redundancy*: for each element of a dataset partition  $\forall a_i \in P_z$  there may exist two visual mapping functions  $F, G$  such that they are applied to the same element of the dataset partition,  $F(a_i) \wedge G(a_i)$ . In this way, the information of the container results redundant, and the interaction effort is meant to reinforce a pattern in data.

*Recursivity*: for each element of a hierarchical partition family  $\forall b_i, b_j \in P$ , such that  $\bigcup b_i \in P_{h1}, \bigcup b_j \in P_{h2}$ , and  $P_{h2} \subset P_{h1}$  a visual mappings family of functions is applied recursively  $F(F(P)) \wedge G(G(P))$ , until a bottom (leaf) partition

visualization is reached. In a dashboard, interacting with selections and filters generates a recursive application of the same charts (the dashboard) on a secondary partition of a dataset.

*Composability:* for each dataset partition  $\forall P_z \in P$ , a visual mappings family of functions is applied to the same dataset partition, by composing two visual mapping functions,  $G(F(P_z))$ . This interaction dimension is applicable to single charts containing more than one visualization principle. However, it can be also applied to dashboards charts.

*Diversity:* for each element of a partition family  $P_{z1} \in P, P_{z2} \in P$ , where  $P_{z1} \neq P_{z2}$  a visual mapping family of functions is applied to each partition,  $F(P_{z1}) \wedge G(P_{z1}) \wedge F(P_{z2}) \wedge G(P_{z2})$ , so as to provide a variety of charts (as in dashboards) for the same dataset, and offering a variety of perspectives around its analysis.

*Complementarity:* for each element of a dataset partition  $\forall a_i \in P_z$  there exists a visual mapping family,  $F(a_i) \wedge G(\bigcup P_z \setminus a_i) \vee F(a_i) \wedge F(\bigcup P_z \setminus a_i)$ , mapping the element and its complement to distinct charts. This configuration allows the interaction with a complete information on the same dataset element.

*Selectivity:* for each element of a partition family  $P_{z1} \in P, P_{z2} \in P$ , where  $P_{z1} \neq P_{z2}$ , there may exist only one between two visual mapping of the same kind,  $F(P_{z1}) \vee F(P_{z2})$  applied to each dataset partition. This configuration allows to select one distinct view for each dataset partition, and allows interacting with one of them at a time (e.g., in dashboards).

What can be seen at this level of abstraction? The opposite poles should be incompatible, i.e., not present at the same time; nearby poles may be compatible, e.g., redundancy and comparability. Open questions remain, like for example: among these configurations, what are the more cognitively intense? What are the most effective when in combination? This should be regarded as future work.

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