ThermalPlot: Visualizing Multi-Attribute Time-Series Data Using a Thermal Metaphor
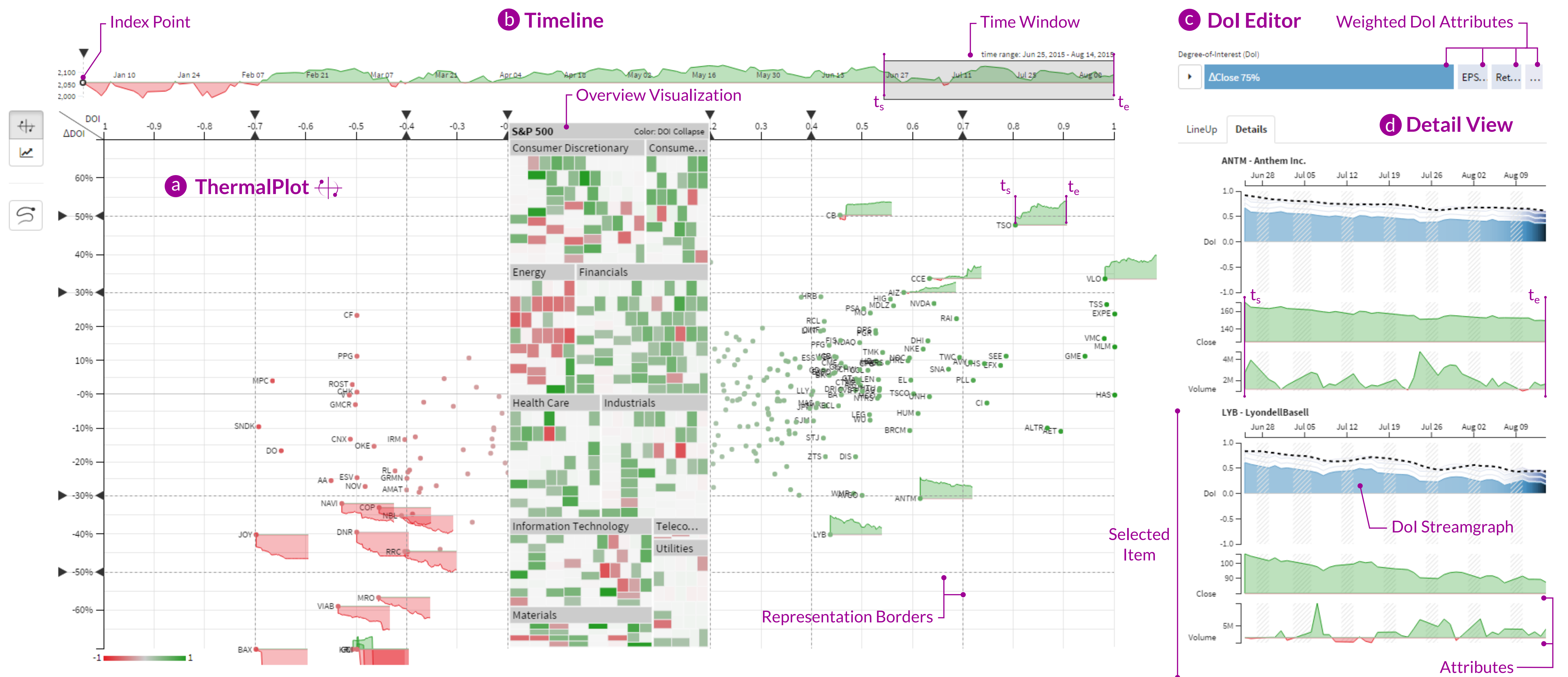
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Figure 1: The *ThermalPlot* technique (a) integrated in the exploration environment for multi-attribute time-series data showing the development of companies listed in the S&P 500 index within a user-specified time window (b). Item positions in the plot are based on the selected index point and the weighted degree-of-interest (DoI) attributes configured with the DoI editor (c). The detail view (d) shows the development of the composed DoI over time as streamgraphs and the line charts of single attributes for selected items.

An important task when making sense of multi-attribute time-series data is to provide users with an overview to identify items that show an interesting development over time. We present *ThermalPlot,* a visualization technique that summarizes complex combinations of multiple attributes over time using an item's position, the most salient visual variable.

We identified two main challenges exists to explore inter-related attributes along with their changes over time:

1. Integration and comparison of multiple heterogeneous attributes for a collection of items. Can be addressed by mapping time to time (aka animation, e.g., [4]), mapping time to space (e.g., [2]), or showing them as small multiples (e.g., [3]).

2. Extraction of temporal dynamics on multiple levels. Can be addressed by superimposing multiple curves in a linechart, by stacking multiple line, or by using other pixel-based techniques [1].

ThermalPlot visualization concept

- Visual space: Degree-of-Interest (DoI) value is mapped to x-axis and ΔDoI value to y-axis (Fig. 2)

- DoI value: Weighted combination of multiple attributes over time, configured with the DoI editor (Fig. 4)

- ΔDoI value: DoI change between the start (t_s) and end (t_e) of a user-defined time window (Fig. 1b)

- Overview visualization: Structures all items as marks in the low DoI range to support location tasks (Fig. 1a)

- Items' level of detail: Configured for all plot regions and changes when crossing a representation border (Fig. 3)

- Meaningful item position by quadrant (Fig. 1a)
  Top-left: Negative development with positive trend
  Top-right: Positive development with positive trend
  Bottom-right: Positive development with negative trend
  Bottom-left: Negative development with negative trend

[1] M. Ankerst et al. Circle Segments: A Technique for Visually Exploring Large Multidimensional Data Sets. In Proceedings of the IEEE Conf. on Visualization (Vis '96), Hot Topic Session. IEEE, 1996.

[2] T. Lammarsch et al. Hierarchical Temporal Patterns and Interactive Aggregated Views for Pixel-Based Visualizations. In Conf. on Information Visualisation (InfoVis '09), pages 44–50. IEEE, 2009.

[3] P. McLachlan et al. LiveRAC: Interactive Visual Exploration of System Management Time-Series Data. In Proc. of the SIGCHI Conf. on Human Factors in Computing Systems (CHI '08), pages 1483–1492. ACM, 2008.

[4] G. Robertson et al. Effectiveness of animation in trend visualization. IEEE Transaction on Visualization and Computer Graphics (InfoVis '08), pages 14(6):1325–1332. IEEE, 2008.
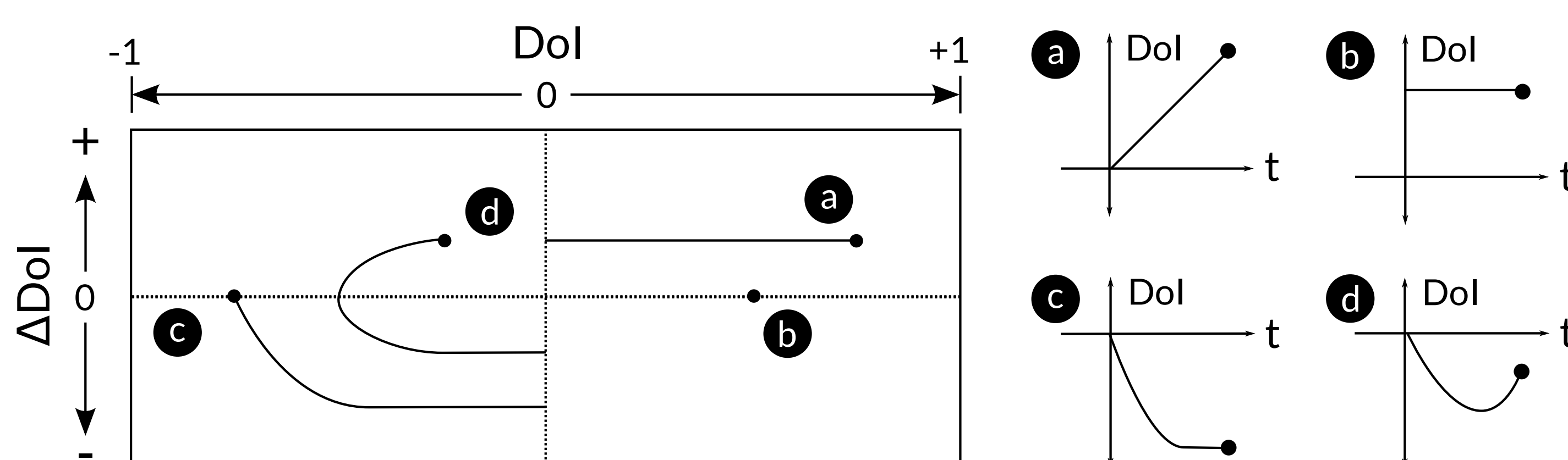
Figure 2
DoI values that change over time result in distinctive positions and trajectories of items in the *ThermalPlot* space.
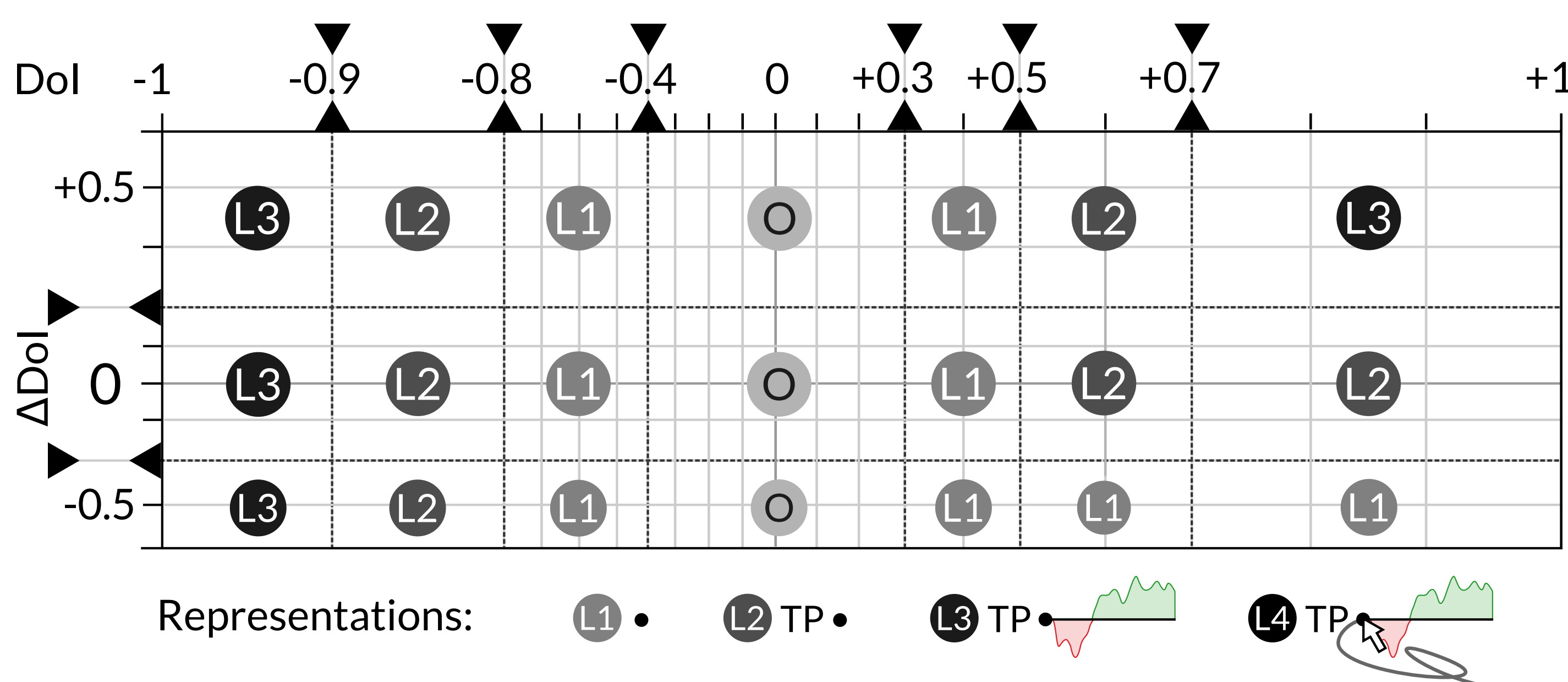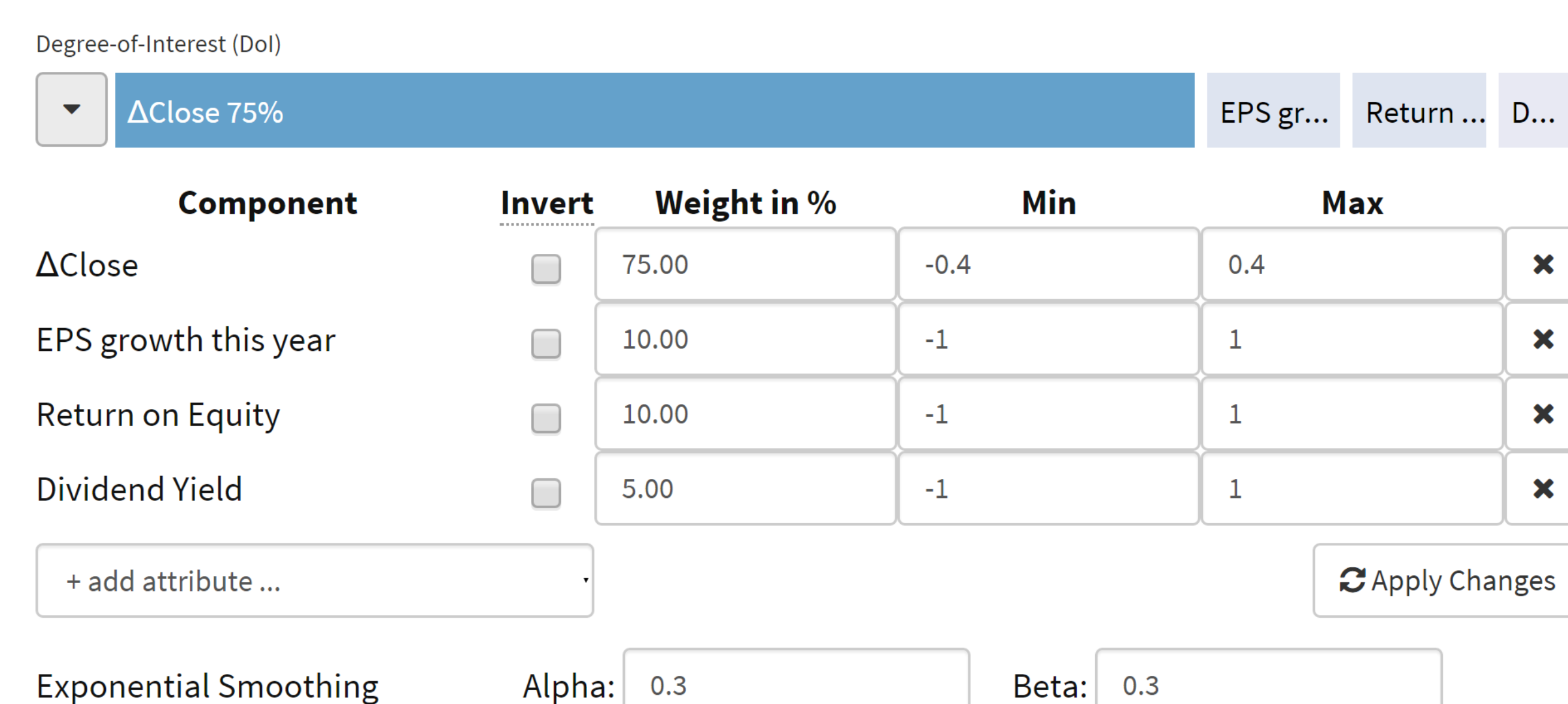

Figure 3
DoI values between [-1,1] are mapped to the x-axis and ΔDoI values with a variable range to the y-axis. The visual space can be geometrically distorted by manipulating the DoI value associated with a representation border. The level of detail in each region of the plot can be configured individually.

Figure 4
Multi-attribute DoI editor with the stacked bar encoding the weighting of individual components (a).

The user can add components, invert the semantic, and set the range for each attribute (b).

Smoothing parameters are applied globally (c).