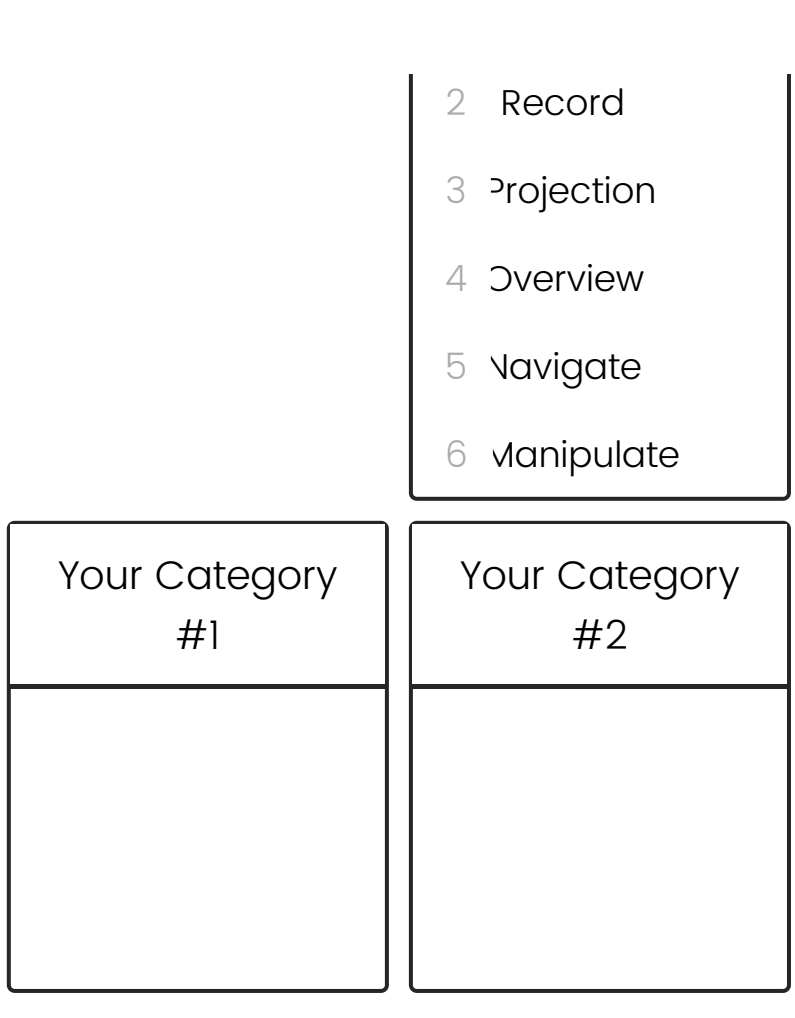
Thank you for your input so far! We have one last section on interactions in data visualizations.

We invite you to categorize a variety of interaction techniques used in information visualization. Please assign each of the interaction types on the left to ONE a category on the right. You can either add them to one of the 3 labeled categories (data interaction, view interaction, workflow interaction) or to unnamed categories, which you can then name yourself farther below. There is no limit on the number of types per category.

Definitions of each **interaction type** and the **three categories** we provide can also be found below.

Items

Data Interaction	View Interaction	Workflow Interaction
1 Select	1 Coordinated views	1 History
2 Aggregate	2 Annotate	
3 Derive	3 Pan	
4 Filter, search & locate	4 Link and brush	
5 Details on demand	5 Distortion	
6 Sort	6 Relate	
7 Visualize/encode	7 Zoom	
8 Extract	8 Highlight	



If applicable, please enter the name for

Your Category #1: n/a

Your Category #2: n/a

Descriptions for the interaction types you grouped above can be found here. We added explanatory language based on the Data Visualization Literacy Framework for clarification (Börner, Bueckle, & Ginda, 2019) at the bottom.

Aggregate: "concerns methods that change the granularity of visualization elements" (Brehmer & Munzner, 2013). Also refers to collecting many units into one. For example, data can be aggregated by ethnicity.

Annotate: "allow textual [or graphical] annotation of states within a visual history" (Heer & Shneiderman, 2012). Also refers to adding explanatory notes or comments to a visualization.

Coordinated views: "enable analysts to see their data from different perspectives" (Heer & Shneiderman, 2012). Also refers to placing individual views or windows in a visualization either completely manually or assisted by an algorithm.

Derive: "compute new data elements given existing data elements" (Brehmer & Munzner, 2013). In our interpretation, this refers to creating variables based on existing ones in the original dataset.

Details on demand: "Select an item or group and get details when needed" (Shneiderman, 1996). This can refer to entire data records or graphical elements representing one or multiple variables.

Distortion: "show portions of the data with a high level of detail and other portions with a lower level of detail." (Keim, 2001).

Extract: "Allow extraction of sub-collections and of the query parameters." (Shneiderman, 1996). This can refer to data records and variables but also parameter and widget settings.

Filter, search & locate: "focusing on specific information within a graphic. It is usually helpful to see a certain graphic under a set of constraints that are defined either by categories or ranges of continuous values" (Wilkinson, 2005).

Highlight: "focus on certain data points (objects) by giving users the ability to change the appearance of object groups in real-time" (Chuah, Roth, Mattis, & Kolojejchick, 1995). This refers to the appearance of graphic symbols and graphic variables.

History: "Keep a history of actions to support undo, replay, and progressive refinement." (Shneiderman, 1996). This refers to the iterative improvement of the entire data visualization.

Link and brush: "coloring or otherwise highlighting a subset of the data [...and] showing information about the highlighted subset in other views" (Buja, Cook, & Swayne, 1996).

Manipulate: "manipulate object set parameters through object handles. Direct manipulation refers to operating directly on objects instead of through menus or dialogues." (Chuah, Roth, Mattis, & Kolojejchick, 1995). Specifically, we consider adjusting position, rotation, and scale of objects (graphic symbols) to be manipulation by interacting with graphic symbols.

Navigate: "visualizations often function as viewports onto an information space. Analysts need to manipulate these viewports to navigate the space", "One common pattern of navigation adheres to the widely cited visual information-seeking mantra: 'Overview first, zoom and filter, then details-on-demand'" (Heer & Shneiderman, 2012, citing Shneiderman, 1996).

Overview: "Gain an overview of the entire collection" (Shneiderman, 1996). We understand this as the ability to quickly get a bird's-eye view of an entire dataset with the option of having context + focus tools (ibid.).

Pan: "change the geographic center of the cartographic representation" (Roth, 2013), "shift the start of the value range to be shown" (Ward & Yang, 2004).

Projection: "set or change the cartographic projection used for the cartographic representation" (Roth, 2013); another good example are "parallel coordinates" (Keim, 2001). We understand this as the ability to adjust the reference system of the visualization from, e.g., a Cartesian to a polar or parallel coordinate system.

Record: "To support iterative analysis, visual analysis tools can record [i.e., capture] and visualize analysts' interaction histories" (Heer & Shneiderman, 2012), "save or capture visualization elements as persistent artefacts" (Brehmer & Munzner, 2013).

Relate: "View relationships among items" (Shneiderman, 1996). We understand this as the ability to turn links in a visualization on and off, or manually create new links.

Select: "demarcation of one or more elements in a visualization, differentiating selected from unselected elements" (Brehmer & Munzner, 2013).

Sort: "Ordering [...] is another fundamental operation within a visualization [...]. The most common method of ordering is to sort records according to the value of one or more variables" (Heer & Shneiderman, 2012).

Visualize/encode: "show me a different representation" (Yi, ah Kang, & Stasko, 2007), "specify a visualization of data: analysts must indicate which data is to be shown and how it should be depicted" (Heer & Shneiderman, 2012). We understand this as the ability to adjust the mapping of data variables to graphic variables of graphic symbols, either for the whole visualization or just a subset of data. It can also mean the change of the visualization type.

Zoom: "change the scale and/or resolution of the cartographic representation" (Roth, 2013), "Through zooming, users can simply change the scale of a representation so that they can see an overview of a larger data set (using zoom-out) or the detailed view of a smaller data set (using zoom-in). A key point here is that the representation is not fundamentally altered during zooming" (Yi, ah Kang, & Stasko, 2007). This can also mean "semantic zoom" where the granularity of the data on display is adjusted rather than the visual representation of that data.

While not every interaction type fits exactly into one category, we can assume that there is a primacy of data, view, and workflow for each of these techniques. Here are our definitions for the three categories we provide.

Data interactions *allow us to modify the number and type of data records as well as data variables that underlie the visualization, based on a range of input parameters. Interaction types that allow the application of analysis algorithms also falls under this category.*

View interactions *allow us to modify the mapping of data records and their variables to graphic symbol types and their graphic variable types.*

Workflow interactions *are neither primarily data-oriented nor visual; they allow the user to manage the progress in the visual analysis process, primarily to communicate insights to collaborators, stakeholders, or oneself when revisiting one's work later. These interactions also let you record, save, and communicate the visualization itself.*

Our **definitions** for some of the terminology above are listed here**:**

Data records are observations in a dataset.

Graphic symbols are of geometric, linguistic, or pictorial nature, and are used to visualize data records and variables.

Graphic variables, e.g., size, color, position, are properties of **graphic symbols** and can be used to encode data variables visually.

Reference system: the basemap of a visualization, e.g., an x-y coordinate plane or a geographic map

Visualization type: refers to tables, charts, graphs, maps, trees, and networks as discussed earlier in this survey.

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Yi JS, ah Kang Y, & Stasko J (2007) Toward a deeper understanding of the role of interaction in information visualization.

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Are there major interaction types missing? If yes, please list them here.

Do you have any comments on the type, naming, and definition

of the three major interaction categories?

Thank you very much for your time!