

# Toward a Deeper Understanding of the Role of Interaction in Information Visualization

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# Motivation

Infovis =  
representation + interaction

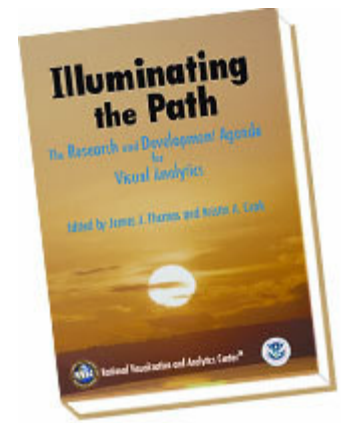
Interaction has been the little brother of Infovis



# Motivation

## Recommendation 3.3: Create a new science of interaction to support visual analytics.

The grand challenge of interaction is to develop a **taxonomy** to describe the design space of interaction techniques that supports the science of analytic reasoning. We must **characterize this design space** and identify under-explored areas that are relevant to visual analytics. Then, R&D should be focused on expanding the repertoire of interaction techniques that can fill those gaps in the design space.



from *Illuminating the Path*. (p. 76)

# Motivation

What is interaction?

# Background

- Interaction

= “The communication between user and the system” [Dix et al., 1998]

= “Direct manipulation and instantaneous change” [Becker et al., 1987]

“HCI research is far from having solid (and falsifiable) theories of interaction” [Beaudouin-Lafon, 2004]

# Background

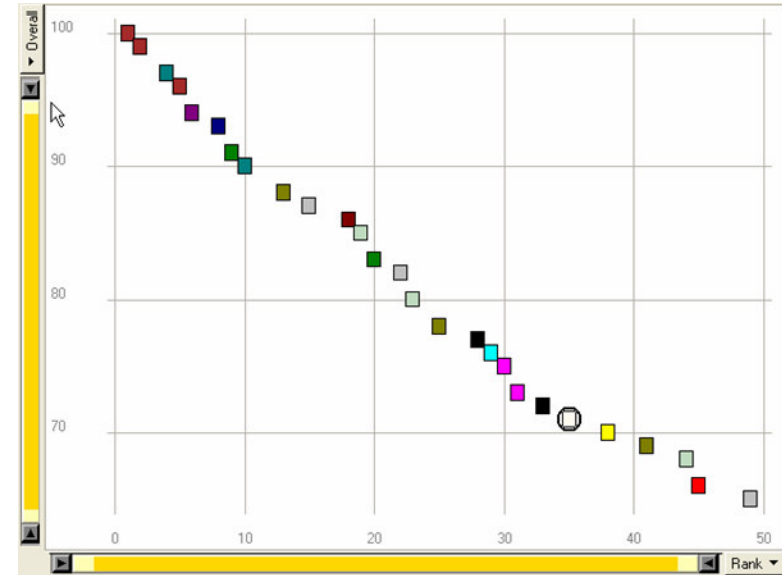
- Interaction techniques in InfoVis
  - Taxonomies of low-level interaction techniques
    - [Shneiderman, 1996]; [Buja, Cook, and Swayne, 1996]; [Chuah and Roth, 1996]; [Dix and Ellis, 1998]; [Keim, 2002]; [Wilkinson, 2005]
  - A taxonomy of interaction operations
    - [Ward and Yang, 2004]
  - Taxonomical dimensions of interaction techniques
    - [Tweedie, 1997]; [Spence, 2007]
  - Taxonomies of user tasks
    - [Zhou and Feiner, 1998]; [Amar, Eagan, and Stasko, 2005]

# Methods

- Survey
  - 59 papers
    - Papers introducing new interaction systems
    - Well-known papers in subareas of Infovis
  - 51 systems
    - Commercial Infovis Systems (SeeIT, Spotfire, TableLens, InfoZoom, etc.)
  - Collected 311 individual interaction techniques
- Affinity Diagram Method

# Methods

- Problems
  - Too many different categories
  - New interaction techniques always come out
  - Representation affects interaction
    - Scatter plot
    - Table lens



Rank	School	Overall	Reputation	Graduation Rank	Freshmen Re
1	Princeton Univer	100	4.9	2	99
2	Harvard Universi	99	4.9	1	96
3	Yale University/C	99	4.9	3	98
4	California Institut	97	4.7	27	97
5	Massachusetts I	96	4.9	10	97
6	Stanford Univers	94	4.9	6	98
6	University of Pen	94	4.5	13	96
8	Duke University	93	4.6	7	97
9	Dartmouth Colle	91	4.4	5	96
10	Columbia Univer	90	4.7	14	97
10	Cornell University	90	4.6	12	96
10	University of Chi	90	4.7	25	94
13	Northwestern Un	88	4.4	10	96
13	Rice University/T	88	4.7	16	95
15	Brown University	87	4.4	7	97
15	Johns Hopkins	87	4.6	18	95
15	Washington Univ	87	4.1	20	96
18	Emory University	86	4	21	97
19	University of Notr	85	3.9	4	98
20	University of Cali	83	4.8	29	95
20	University of Virni	83	4.4	9	97
22	Vanderbilt Univer	82	4.1	31	91
23	Cornell Mellon	80	4.2	41	91
23	Georgetown Uni	80	3.9	15	96
25	U. of North Carol	78	4.2	28	95
25	Univ. of Californi	78	4.3	30	96
25	University of Mic	78	4.5	24	95





# Methods

## More examples

### - Different techniques

- Unfolding sub-categories in an interactive pie chart
- Drill-down in Treemap
- Zooming-in in Google Earth
- Tooltip in SeeIT

### - Something similar

Getting more details

## User intent

“What a user wants to achieve through a specific interaction technique.”

# Results

## 7 categories

*Select*

*Explore*

*Reconfigure*

*Encode*

*Abstract/Elaborate*

*Filter*

*Connect*

# *1. Select*

“Mark something as interesting”

- Mark items of interest to keep track
- Seem to work as a preceding action to subsequent operations.

e.g.,

- Selecting a placemark in Google Map
- The Focus feature in TableLens

# 1. Select

The image shows a screenshot of a TableLens interface. The table has eight columns: Rank, School, Overall, Reputation, Graduatio..., Freshme..., Top 10% ..., and Acceptan... Each cell in the table contains a blue horizontal bar representing data. A mouse cursor is hovering over a cell in the School column, which is highlighted in cyan. The bars vary in length, indicating different values for each metric across the rows.

TableLens

## 2. Explore

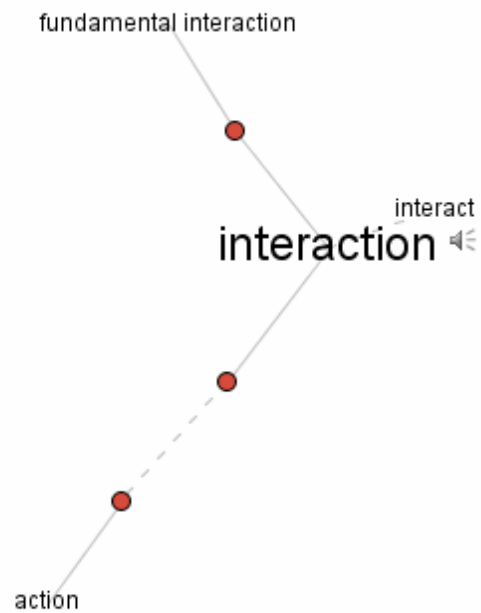
“Show me something different”

- Enable users to examine a different subset of data
- Overcome the limitation of display size

e.g.,

- Panning in Google Earth
- Direct Walking in Visual Thesaurus

# 2. Explore



Visual Thesaurus

## 3. Reconfigure

“Show me a different arrangement”

- Provide different perspectives by changing the spatial arrangement of representation

e.g.,

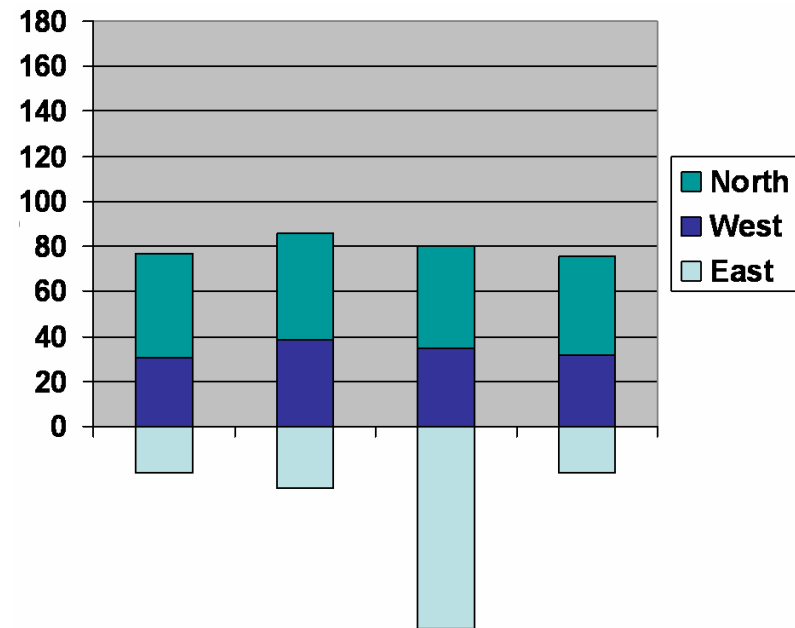
- Sorting and rearranging columns in TableLens
- Changing the attributes in a scatter plot
- The baseline adjustment feature in Stacked Histogram
- The “Spread Dust” feature in Dust & Magnet



# 3. Reconfigure

Rank	School	Overall	Reputation	Graduation Rank	Freshmen Re
1	Princeton Univer	100	49	2	99
2	Harvard Universi	99	49	1	96
2	Yale University/C	99	49	3	98
4	California Institut	97	47	27	92
5	Massachusetts I	96	49	10	97
6	Stanford Univer	94	49	6	98
6	University of Pen	94	45	13	96
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9	Dartmouth Colle	91	44	5	96
10	Columbia Univer	90	47	14	97
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10	University of Chi	90	47	25	94
13	Northwestern Un	88	44	10	96
13	Rice University/T	88	42	16	95
15	Brown University	87	44	7	97
15	Johns Hopkins	87	46	18	95
15	Washington Univ	87	41	20	96
18	Emory University	86	4	21	92
19	University of Nint	85	39	4	98
20	University of Cali	83	48	29	95
20	University of Virni	83	44	9	97
22	Vanderbilt Univer	82	41	31	91
23	Cornelia Mellon	80	42	41	91
23	Georgetown Uni	80	39	15	96
25	U. of North Carol	78	42	28	95
25	Univ. of Californi	78	43	30	96
25	University of Mic	78	45	24	95

TableLens



Stacked Histogram

## 4. Encode

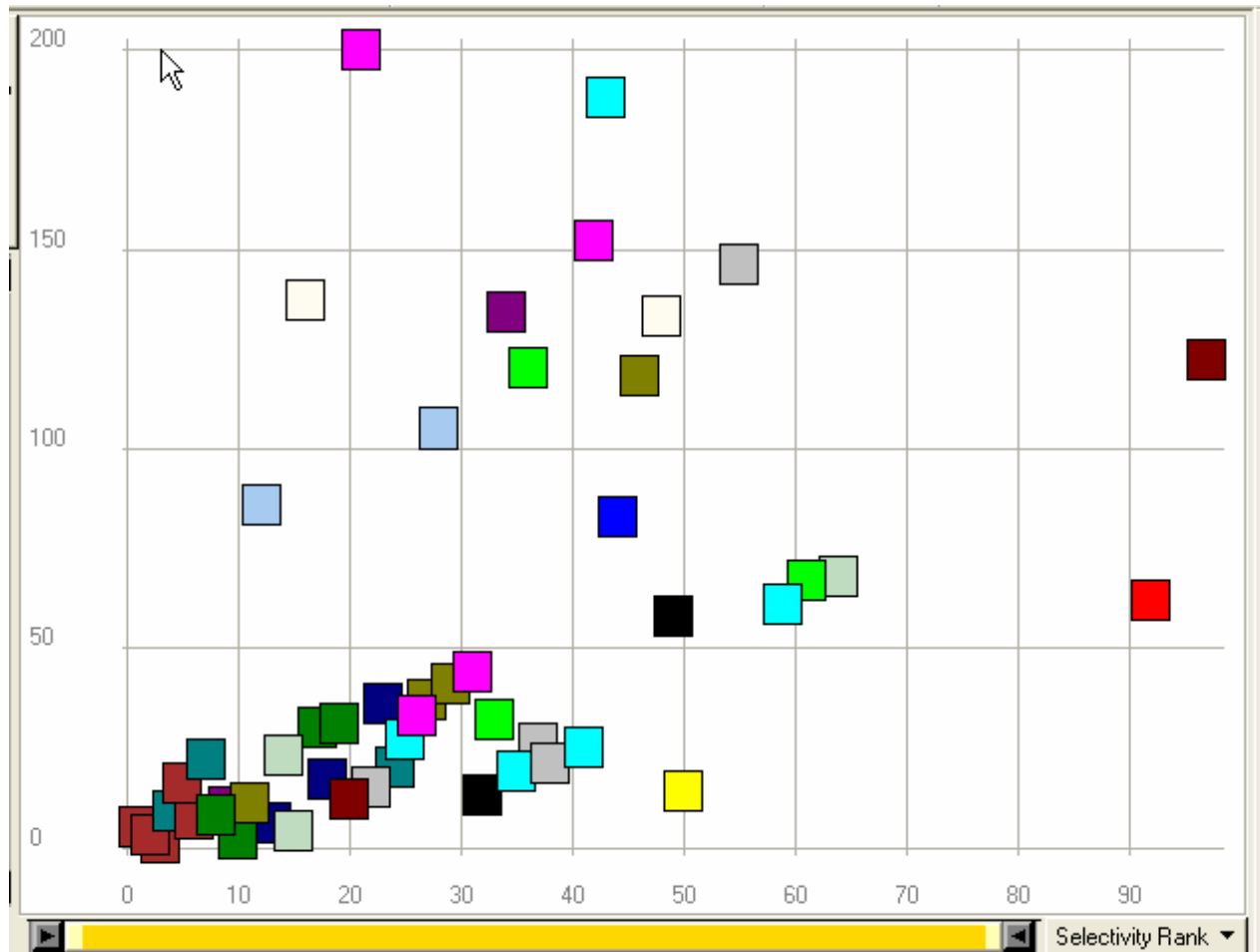
“Show me a different representation”

- Change visual appearances

e.g.,

- Changing color encoding
- Changing size
- Changing orientation
- Changing font
- Changing shape

# 4. Encode



Spotfire



## 5. *Abstract/Elaborate*

“Show me more or less detail”

- Adjust the level of abstraction (overview and details)

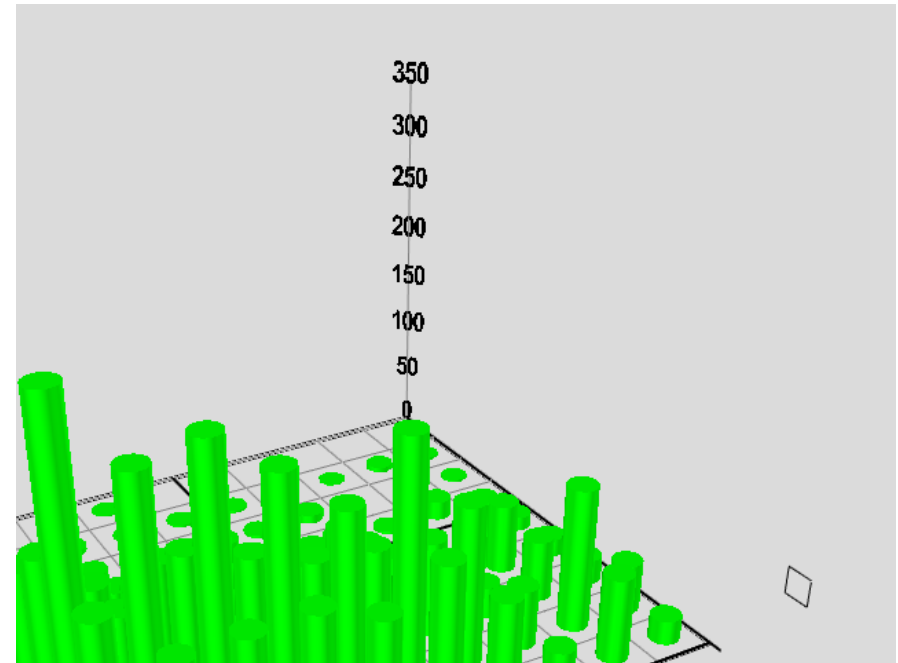
e.g.,

- Unfolding sub-categories in an interactive pie chart
- Drill-down in Treemap
- Details-on-demand in Sunburst
- The tool-tip operation in SeeIT
- Zooming (geometric zooming)

# 5. Abstract/Elaborate



Google Earth



SeeIT

## 6. Filter

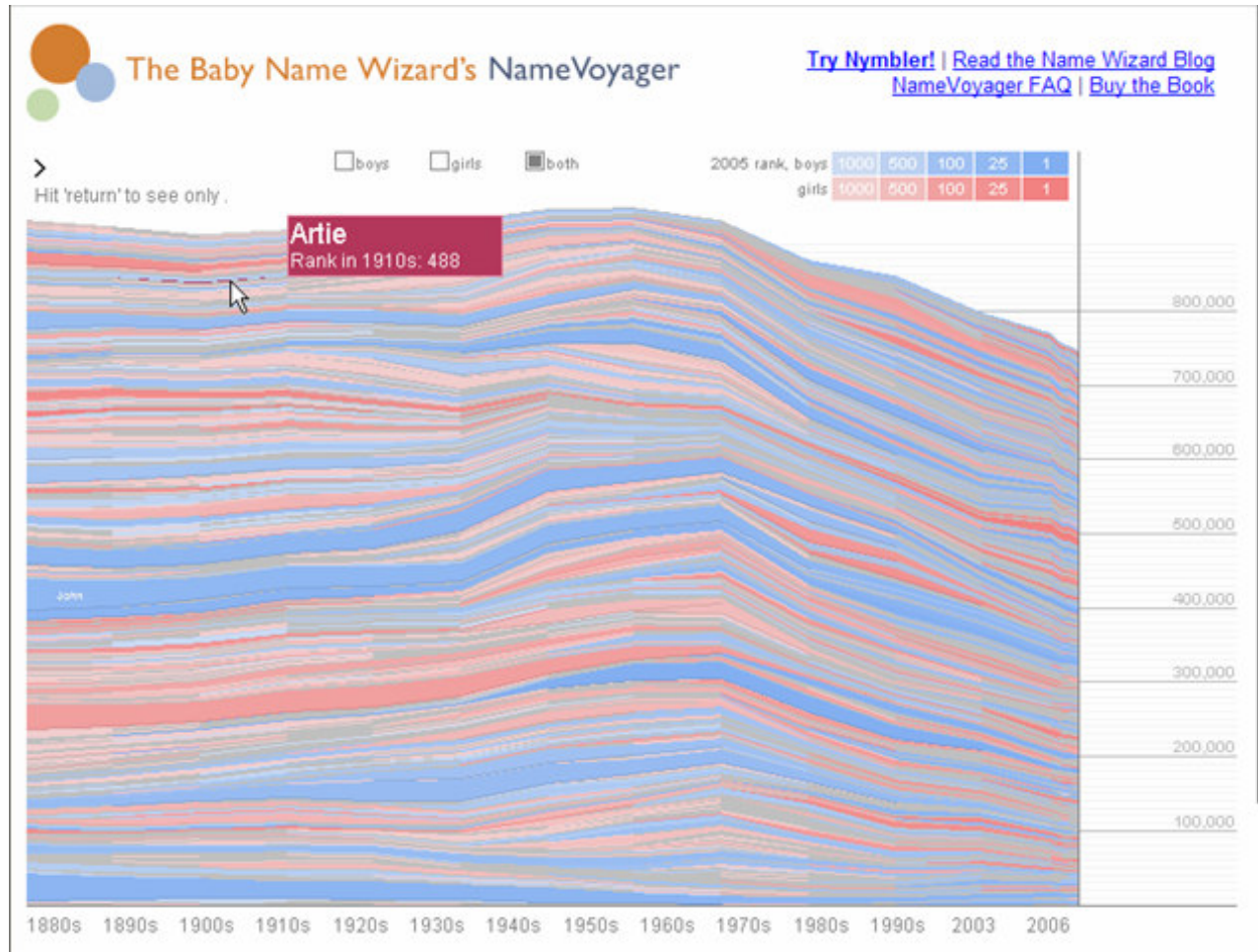
“Show me something conditionally”

- Change the set of data items being presented based on some specific conditions.

e.g.,

- Dynamic query
- Attribute Explorer
- Keystroke based filtering in NameVoyager
- QuerySketch

# 6. Filter



NameVoyager

## 7. Connect

“Show me related items”

- highlight associations and relationships
- show hidden data items that are relevant to a specified item

e.g.,

- Highlighting directly connected nodes in Vizster
- Brushing in InfoZoom



# 7. Connect



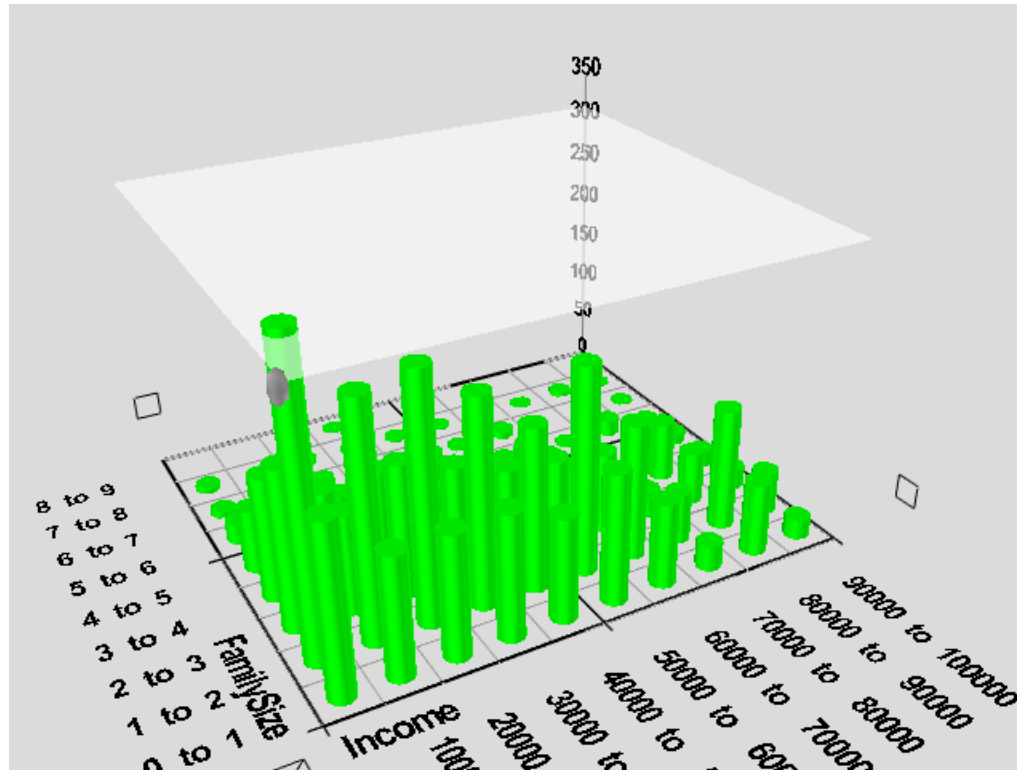
InfoZoom

# Discussion

- Not a formal taxonomy
- What are not in these categories?
  - Undo/redo/history  
Annotation  
Change configuration
  - Compare

# Discussion

- Exceptions? Yes
  - Water level in SeeIT



- Semantic zooming

# Conclusions

- Draw attention to the importance of interaction and reveal its subtle complexity
  - Infovis = representation x interaction
- Introduced a (user) intent-based categorization of interaction
- Still debatable, but an initial step
- Hopefully, useful for Infovis design

# Conclusions

*Reconfigure*

*Encode*

*Filter*

*Abstract/Elaborate*

*Connect*

*Explore*

*Select*

***REFACES***



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# Q&A

Thank you for your attention!