

Opening the Black Box of Interaction in Visualization

Hans-Jörg Schulz¹, Tatiana v. Landesberger², Dominikus Baur³

VIS Tutorial 2014



TECHNISCHE
UNIVERSITÄT
DARMSTADT

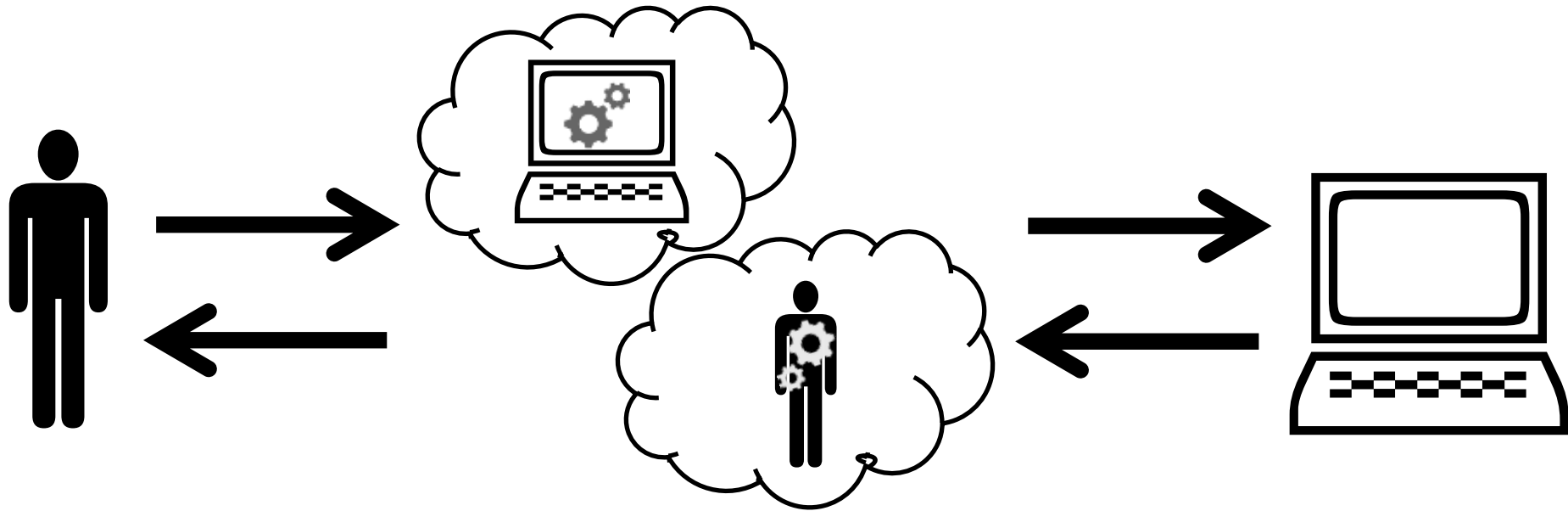


1. Fraunhofer IGD, Rostock, Germany
2. TU Darmstadt, Darmstadt, Germany
3. Dominikus Baur Interfacery

PART I: INTERACTION ACTIVITIES

Speaker: Tatiana von Landesberger

Part 1: Interaction activities

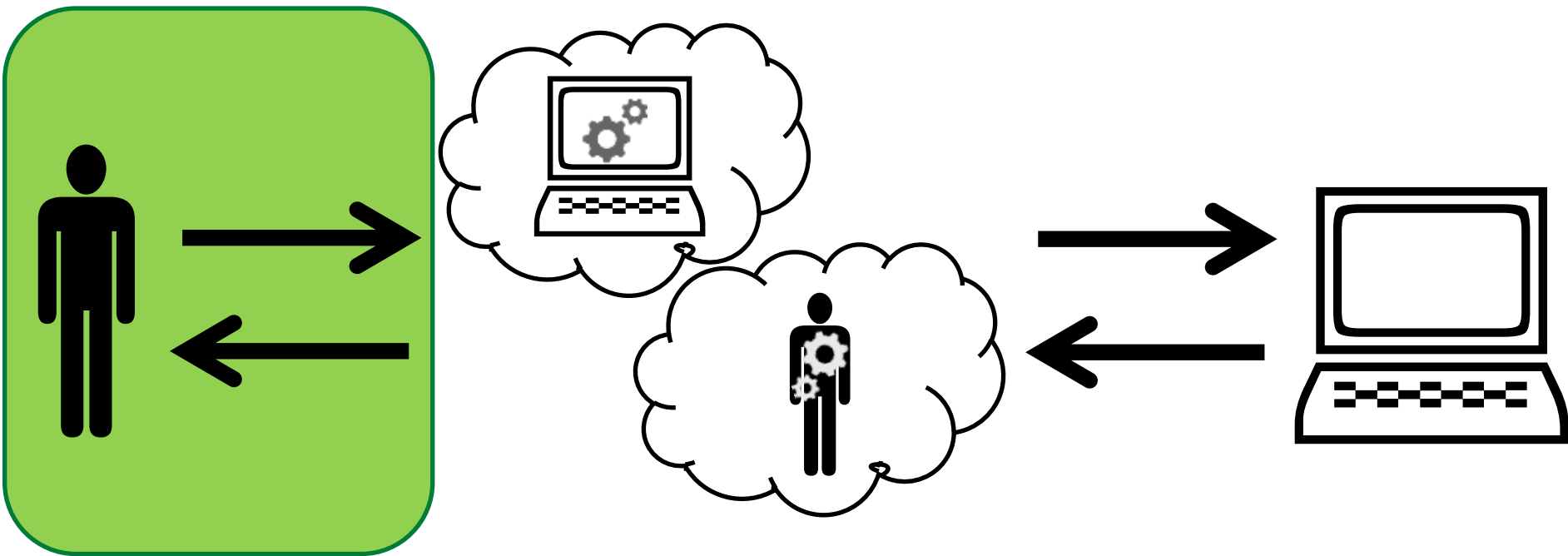


Activities: What the user does to trigger a change in the computer (*Action*)

Metaphor: What the user thinks the computer is doing and vice versa (*Understanding*)

Architecture: What the computer actually does (*Reaction*)

Part 1: Interaction activities



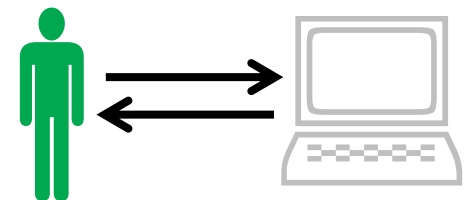
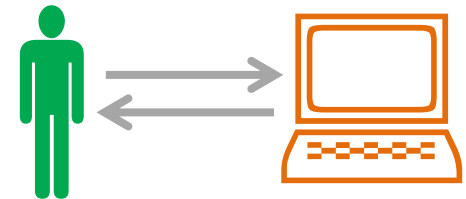
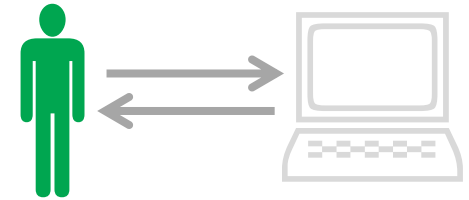
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Architecture: What the computer actually does (*Reaction*)

Overview of Part 1

- 6W's of User's Interaction and interaction loop
- Systematization of interaction
 - Human (Ws) and System (Vis)
 - Vis/VA-focused systematizations:
 1. Visualization, 2. Visual Data Mining
 3. Reasoning
- Third view: Interaction Support



Motivation

- System developers:
 - What to include in my system
- Researchers:
 - What is there and what is missing
- Users:
 - What to expect from the system
- Developers, researchers,...:
 - Canonikum for evaluation and system testing

Motivation

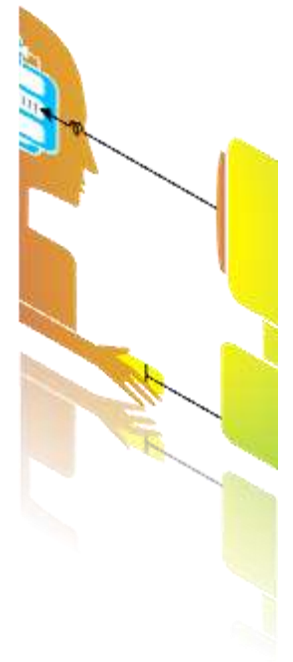
Make it easier for you...

Systematization of perspectives ...



What is interaction from user's point of view?

USER'S ACTION AND THE INTERACTION LOOP



<http://www.smartgirl.org/brain-food/career-hubs/human-computer-interaction.png>

6Ws of Interaction

WHY do we interact?

What is the goal?

WHAT is the purpose?

What is the intended effect of interaction?

HOW do we interact?

Which means do we use/have at disposal?

WHO interacts?

Who are the users interacting? What is their background?

WHEN do we interact?

When is interaction needed?

WHERE is interaction used?

Where users interact?

Effects and
means

Context of
interaction

[adapted & merged
Roth13, Jansen et al
13]

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Context of
interaction

[adapted & merged from
Roth13, Jansen et al 13]

Hierarchic View on Interaction

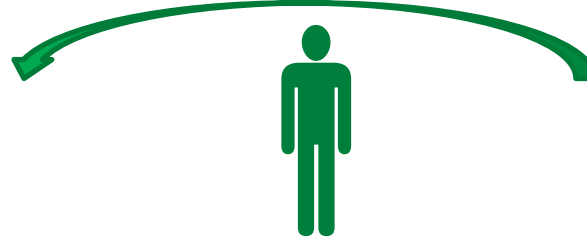
WHY do we interact?

WHAT is the purpose?

 **HOW** do we interact?

Norman's Model of Interaction

8. Take further action
(compare outcome with goal)



EXECUTION

1. Establish a goal
(Why?)
2. Form intention/identify task
(What?)
3. Specify action sequence
(How?)

Execution/
Evaluation loop



4. Execute action

EVALUATION

7. Evaluate the outcome
(Why?)
6. Interpret the system's state
(What?)
5. Perceive the state of the system
(How?)

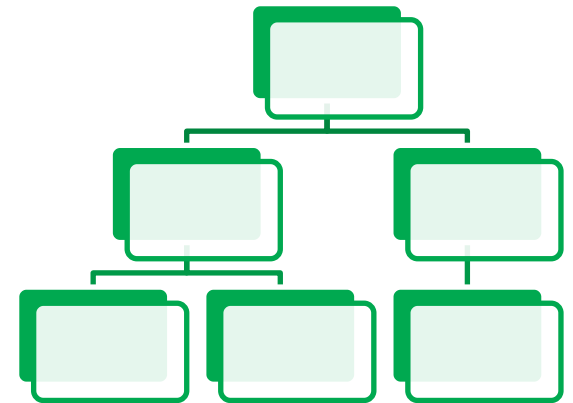
[Norman88]

Preliminary Summary

1. 6Ws of interaction:
 1. Effects+means: Why?, What? How?
 2. Context: Who? Where? When?
2. Hierarchic nature of interaction
3. Execution/Evaluation loop

Which interactions exist?

INTERACTION SYSTEMATIZATION



TWO VIEWS ON INTERACTION

What is interaction → Systematization

1. 6Ws of interaction:
 1. Effects+means: Why?, What? How?
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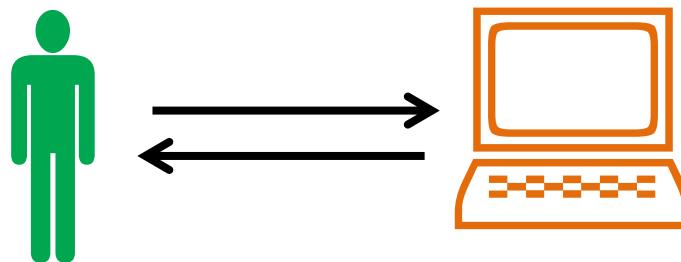
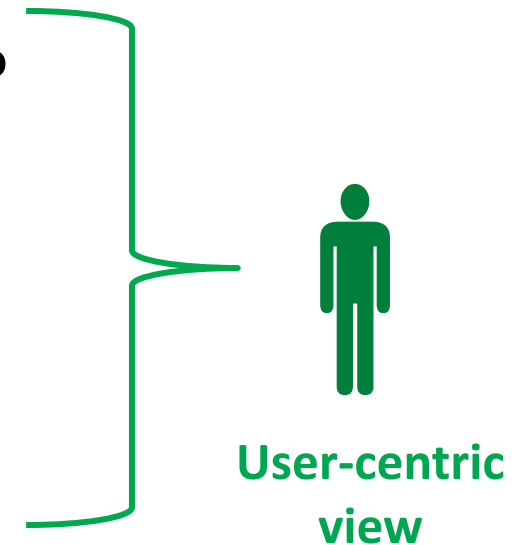
What is interaction → Systematization

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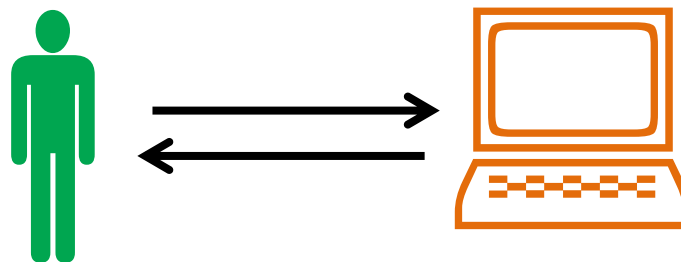
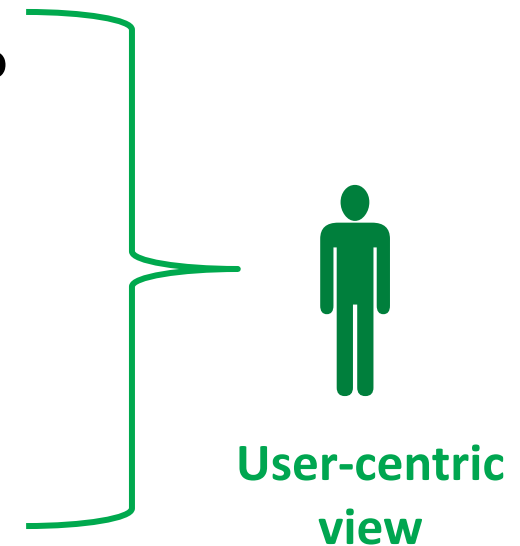
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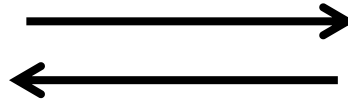
2. Hierarchic nature of interaction

3. Execution/Perception loop



Visualization side?

Human ↔ Visualization



WHY

Subjective perception

Visualization changes

WHAT

What should be modified in the view (goal/intention)

What in the visualization is modified

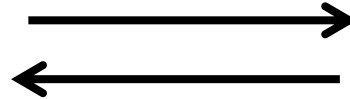
HOW

How it should be modified (which action)

How this is done (software/hardware)

[adjusted Roth13]

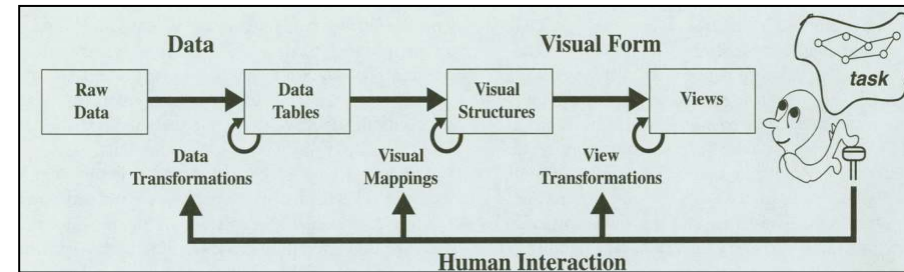
Human ↔ Visualization



WHY

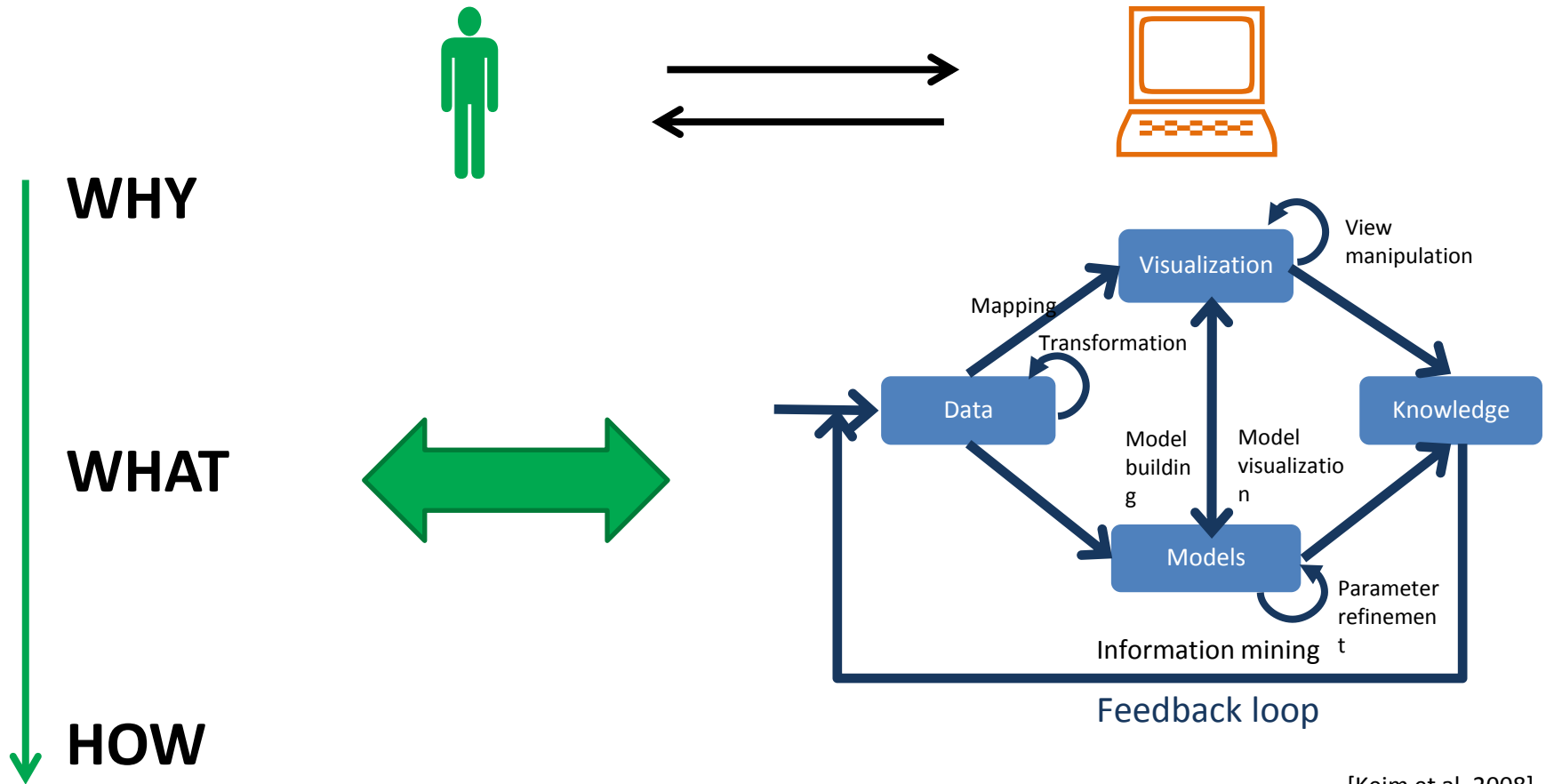
WHAT

HOW



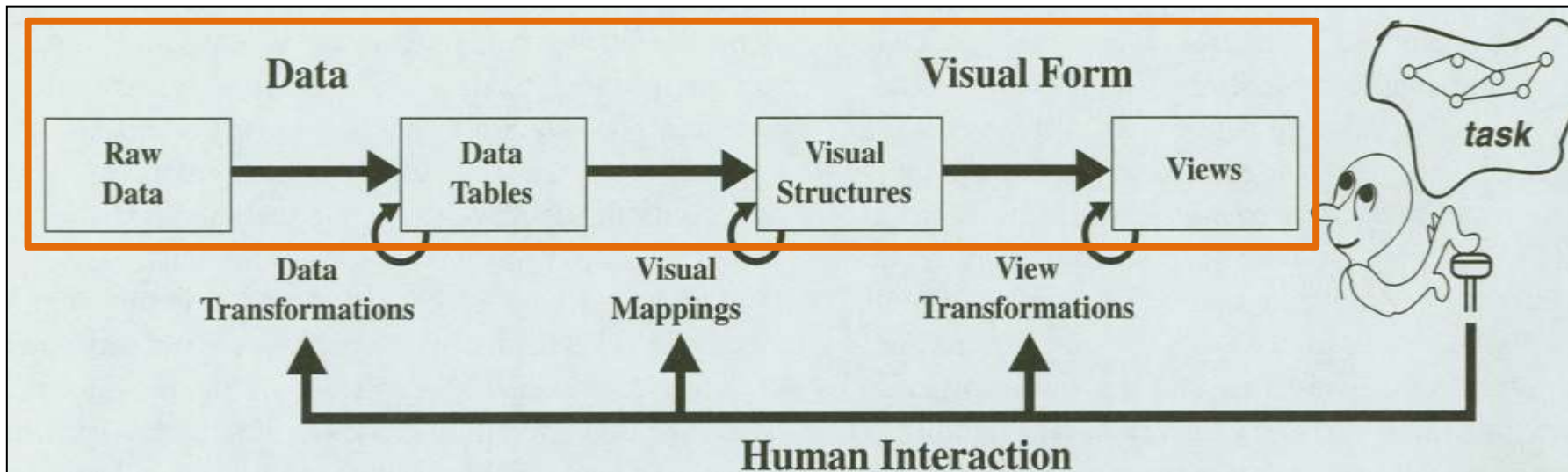
[Card et al.99]

Human ↔ Visual Analytics



[Keim et al. 2008]

Information Visualization Model

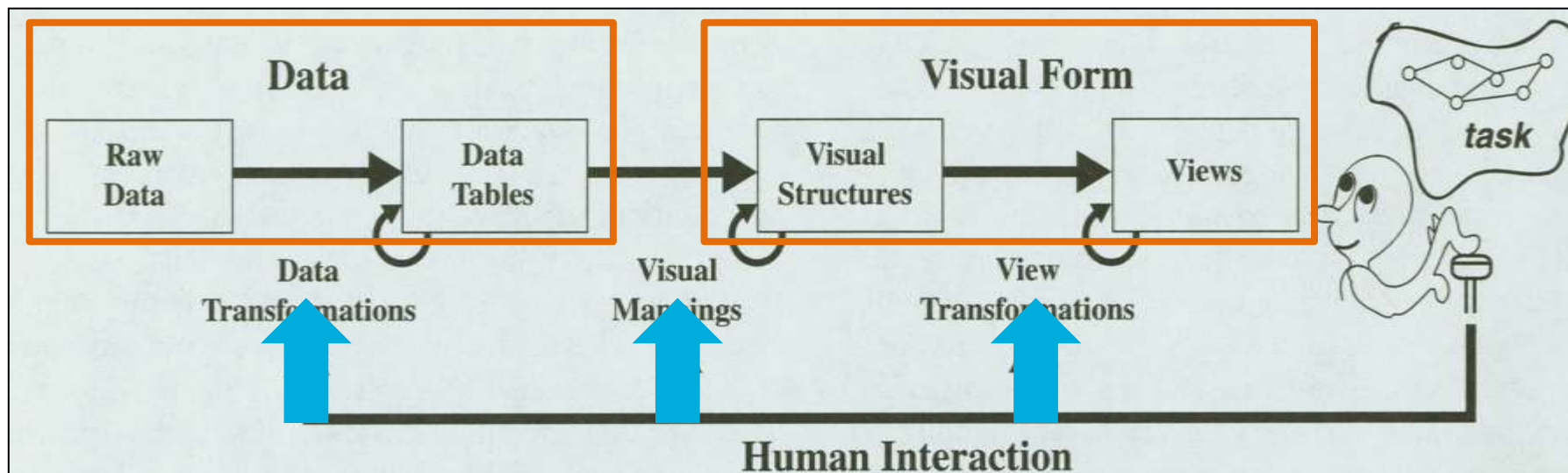


[Card et al.99]

Information Visualization Model

Data

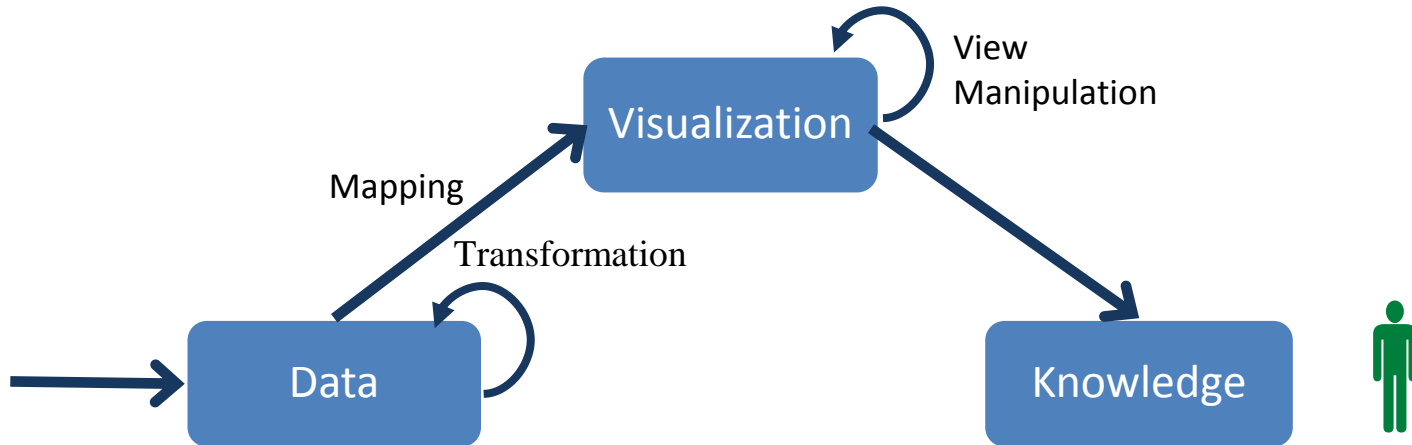
Visual



[Card et al.99]

Visualization → Visual Analytics

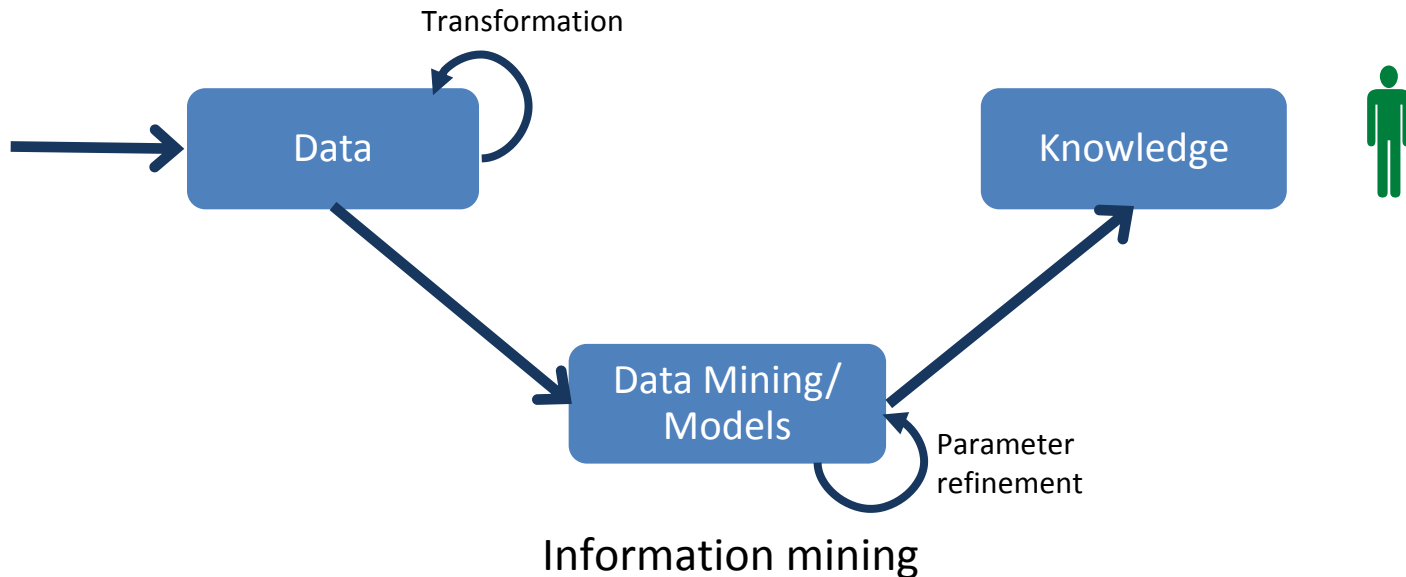
Simple Information Visualization Model



[Keim et al. 2008]

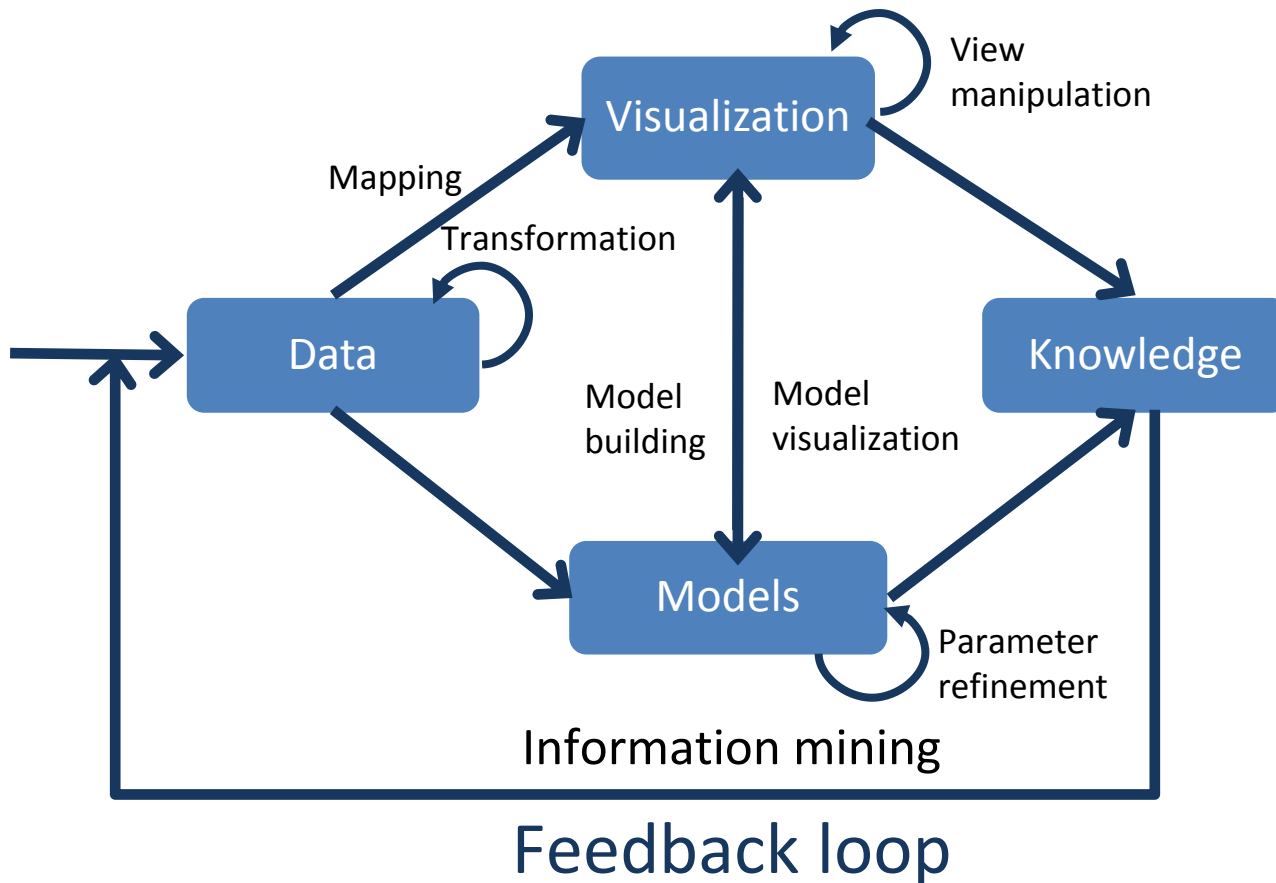
Visualization → Visual Analytics

Simple Data Mining Model



[Keim et al. 2008]

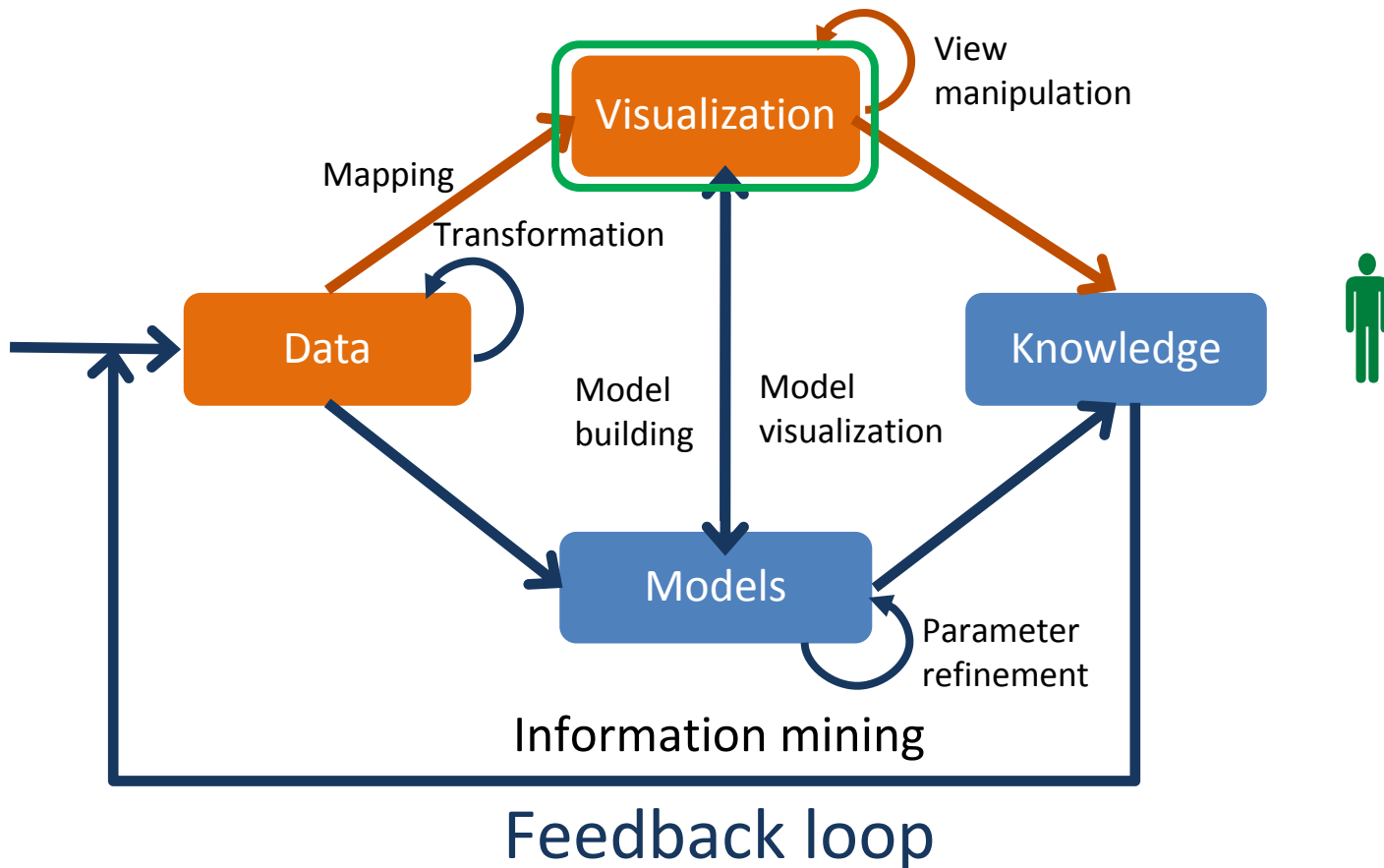
Visual Analytics Model



[Keim et al. 2008]

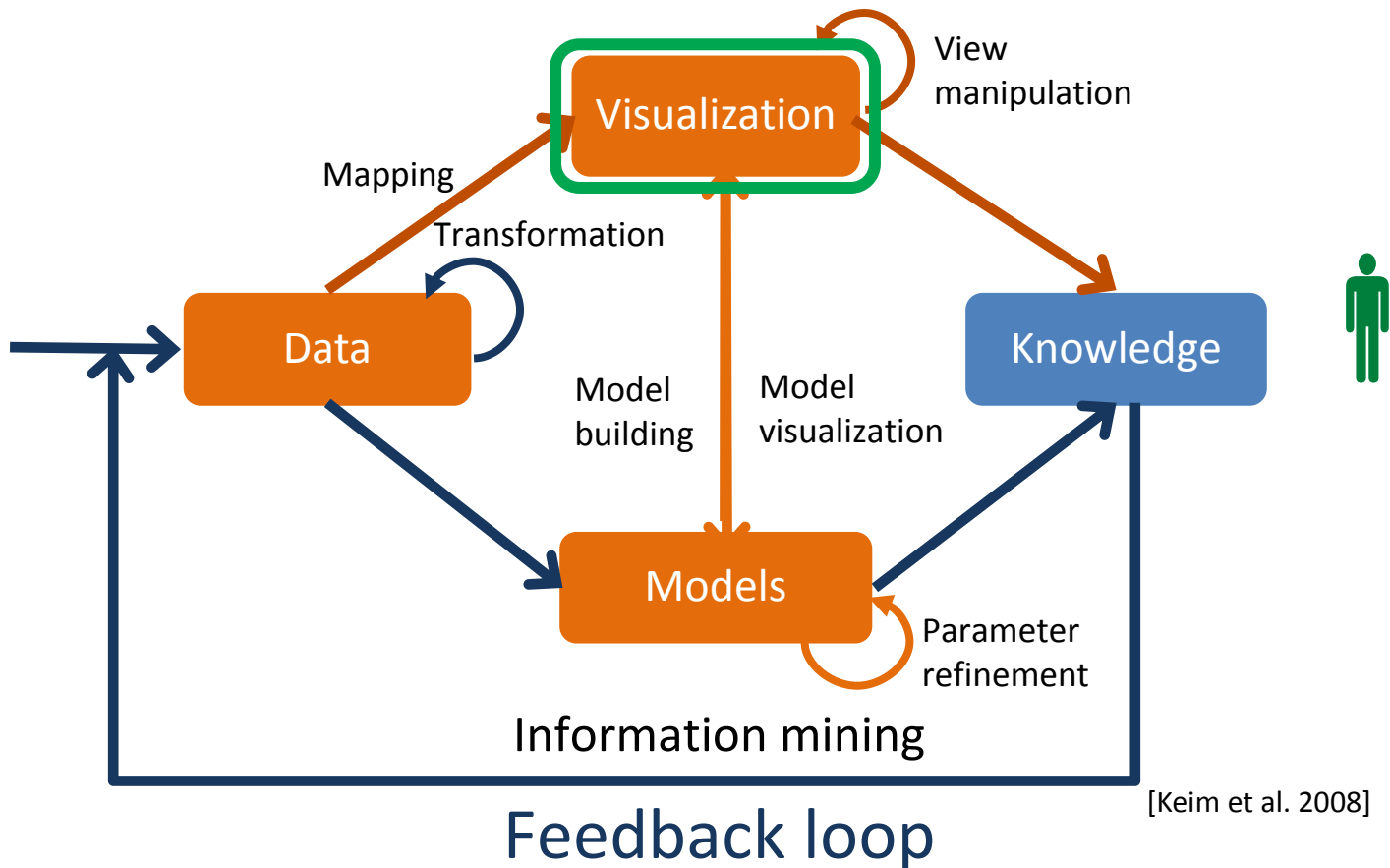
3 Ways of Visual Analytics

Way 1: InfoVis



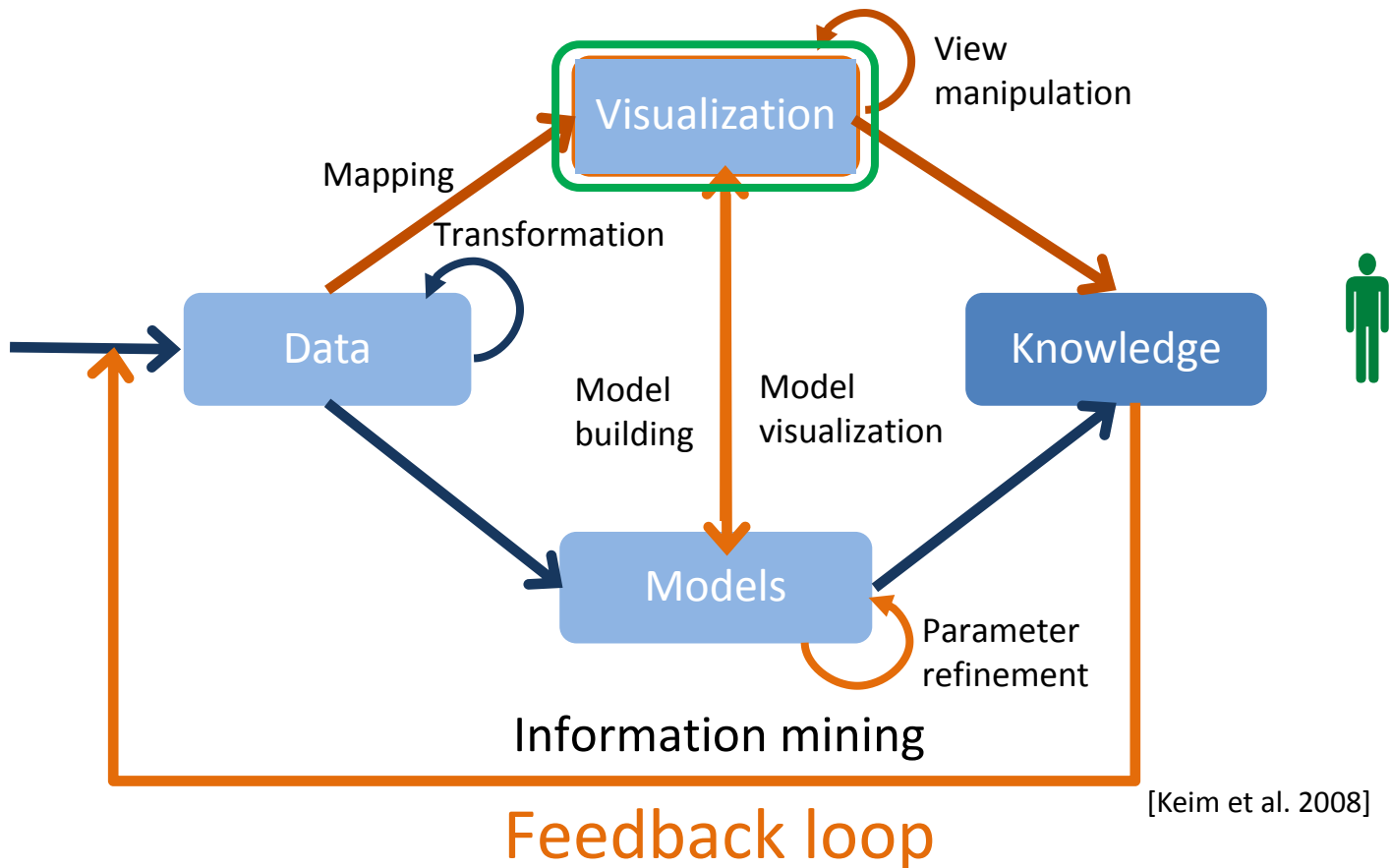
3 Ways of Visual Analytics

Way 2: Visual Data Mining



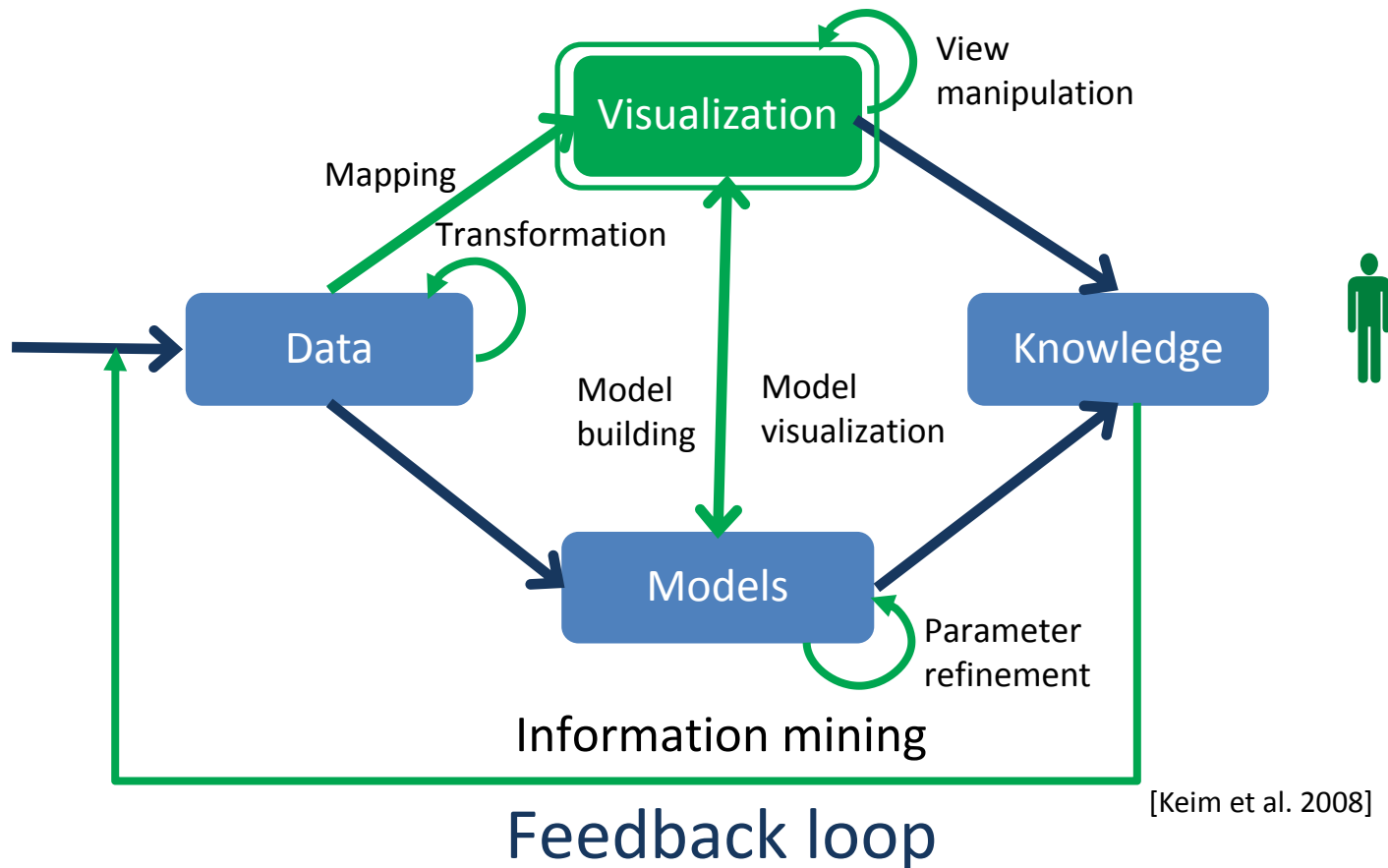
3 Ways of Visual Analytics

Way 3: Provenance/Sensemaking/Reasoning

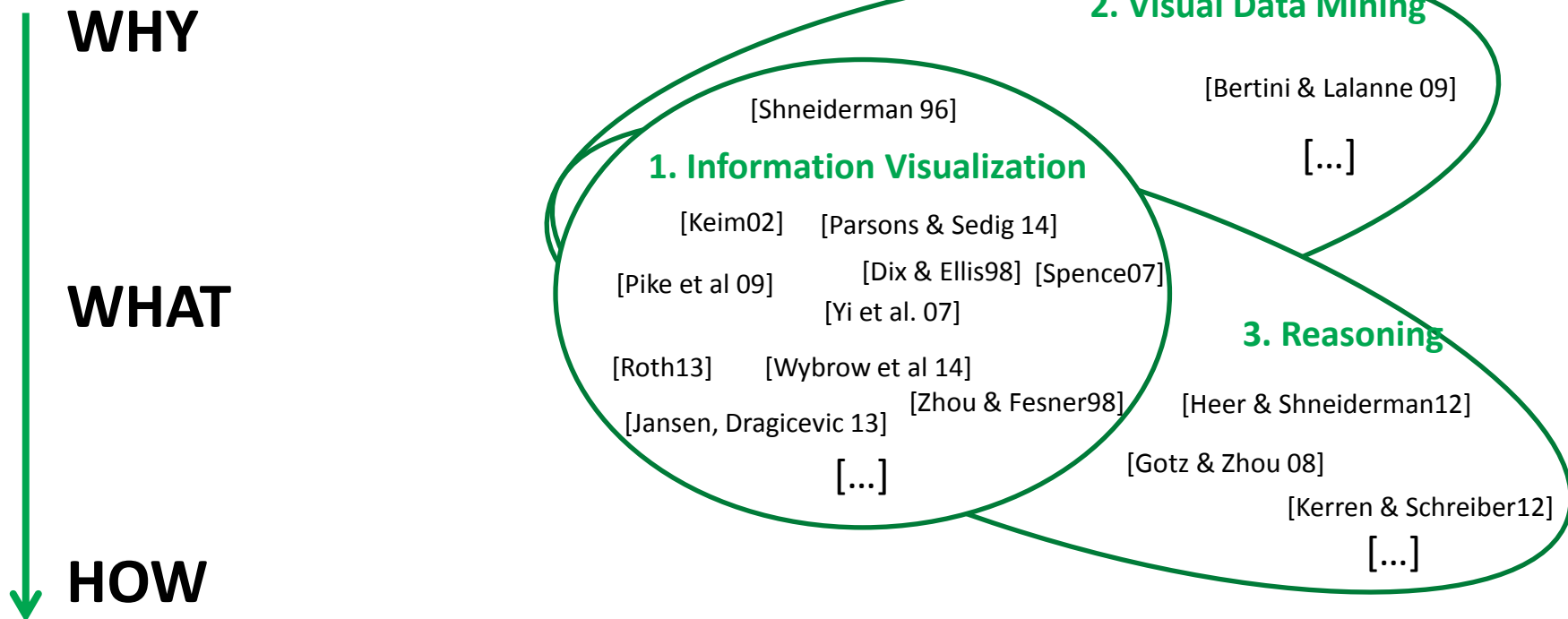


Interaction Need in Visual Analytics

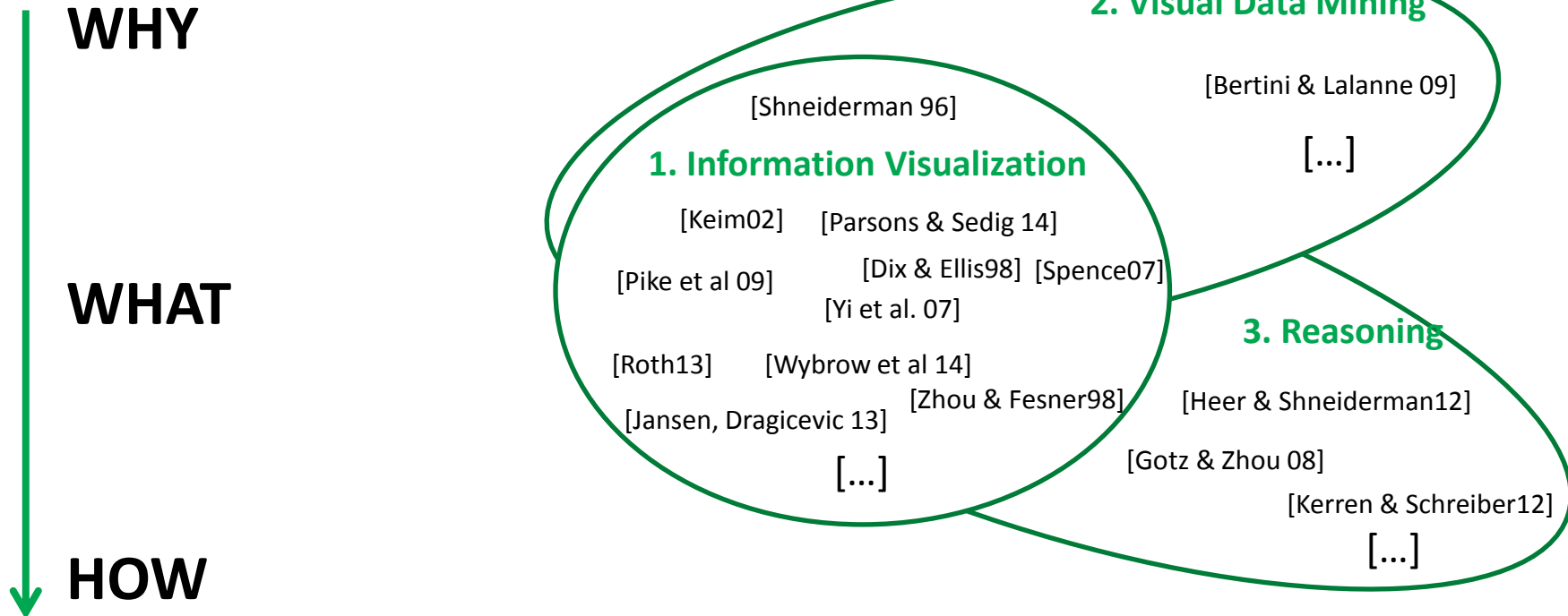
Support all 3 ways via visual means



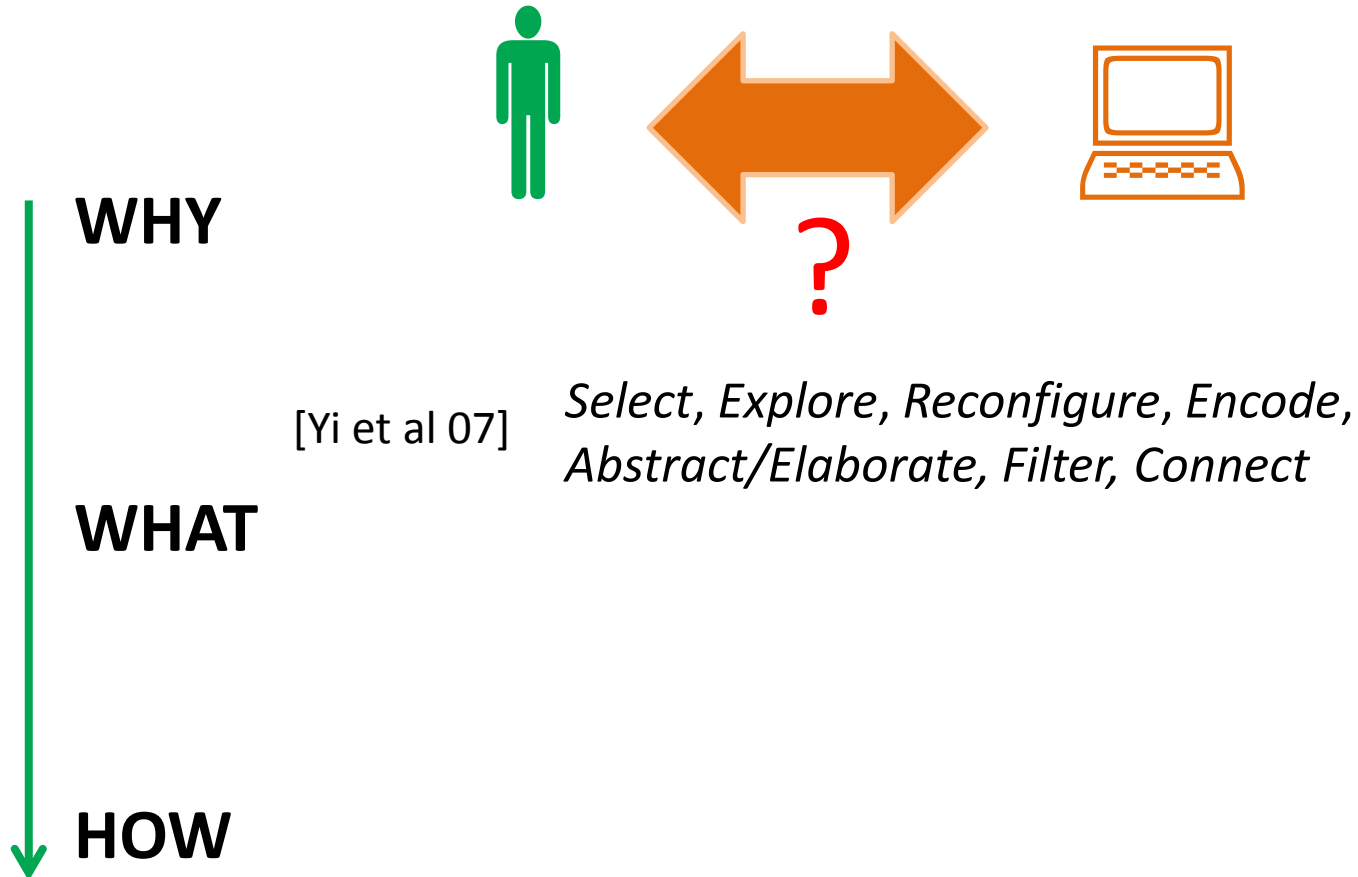
Systematization of Interaction



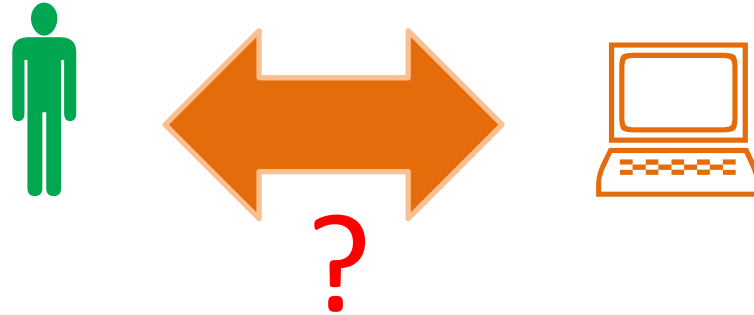
Systematization of Interaction



Levels of Systematization: Example



Levels of Systematization: Problem of ambiguous terms



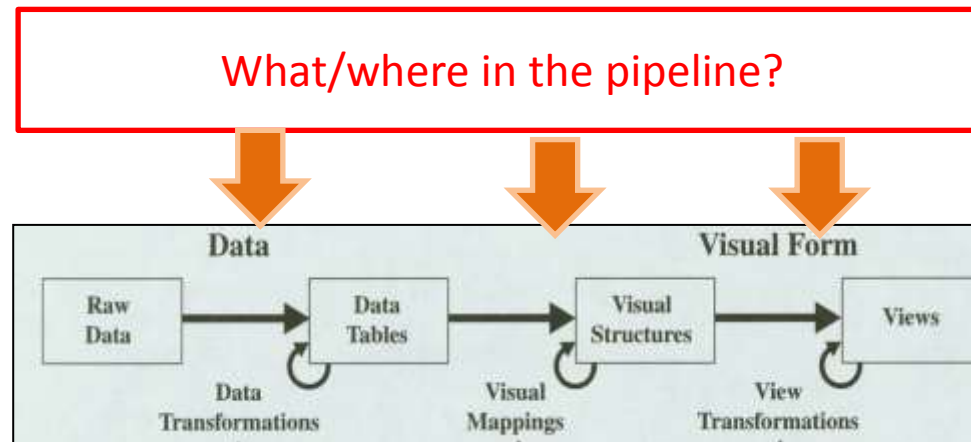
WHY

[Yi et al 07] *Select, Explore, Reconfigure, Encode, Abstract/Elaborate, Filter, Connect*

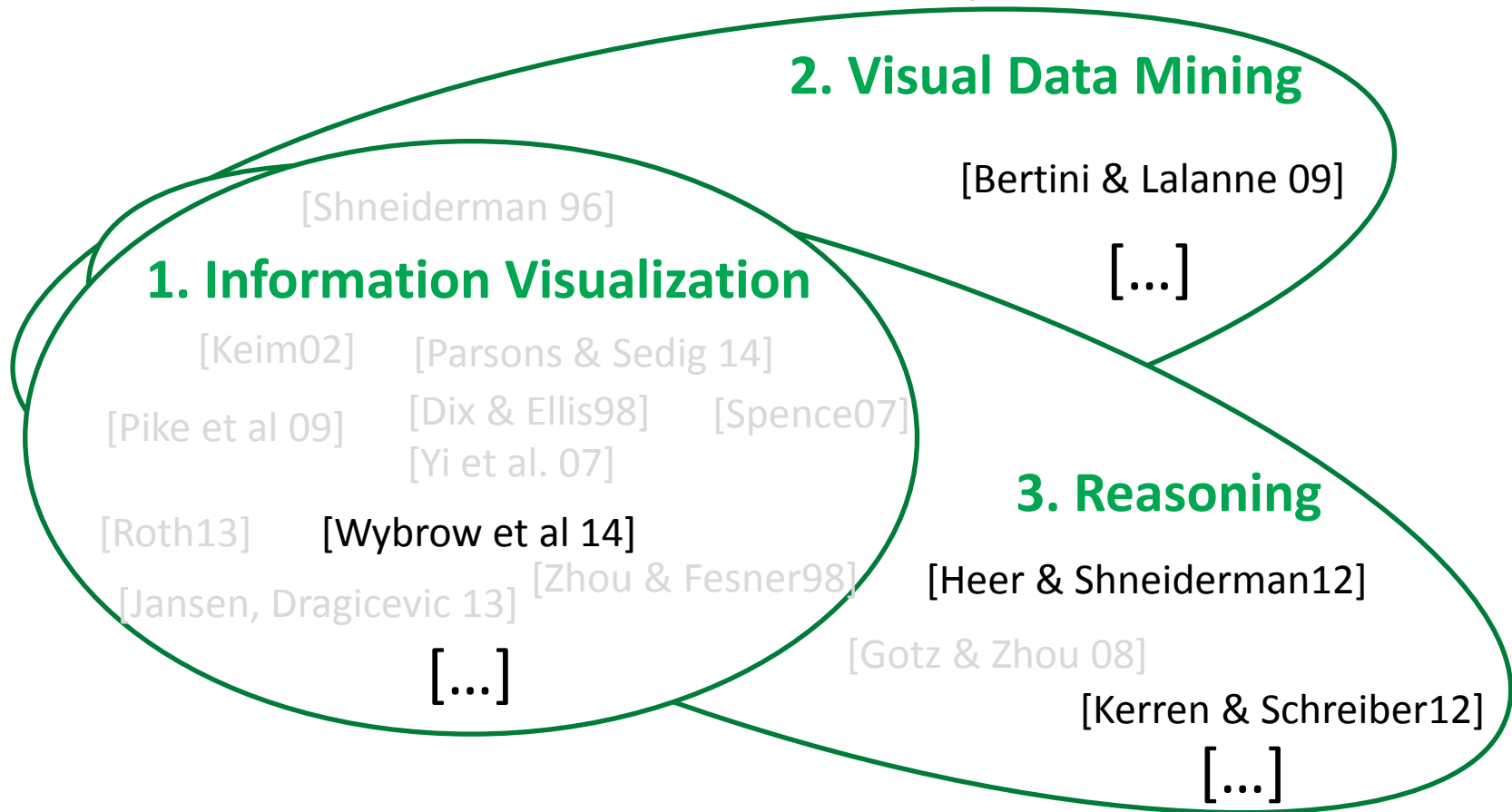
WHAT

What/where in the pipeline?

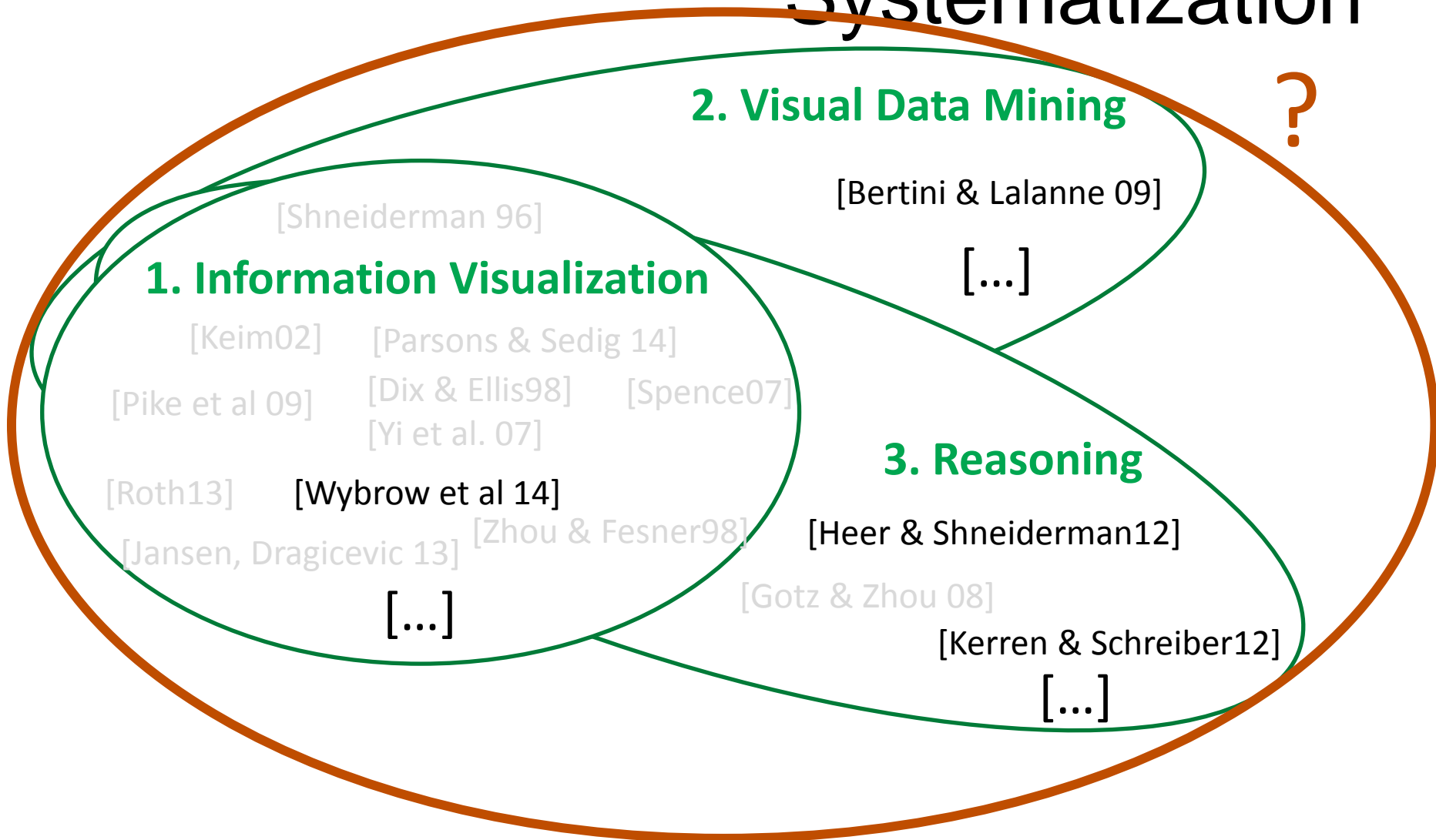
HOW



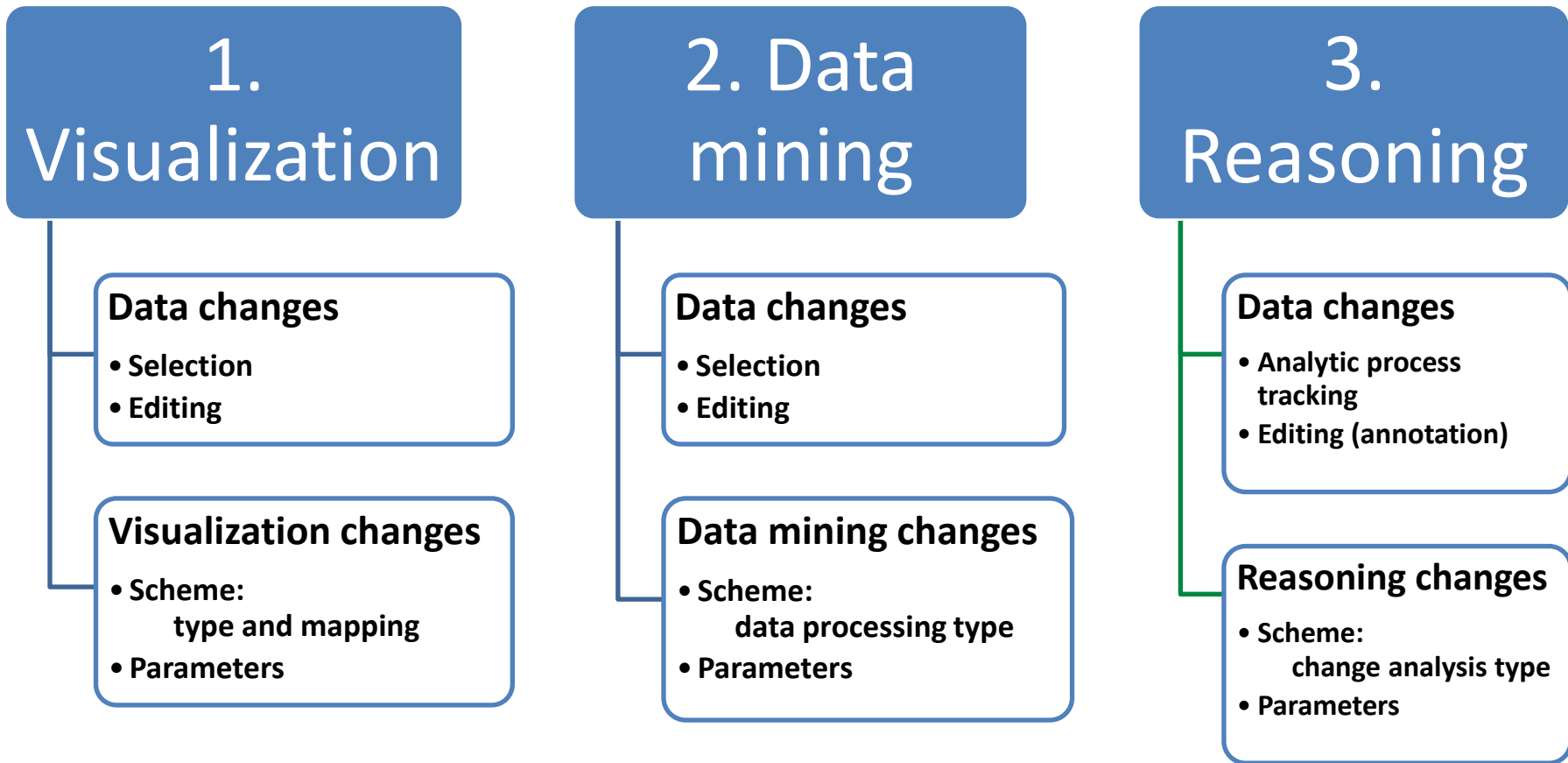
Pipeline-Focused Interaction Systematization



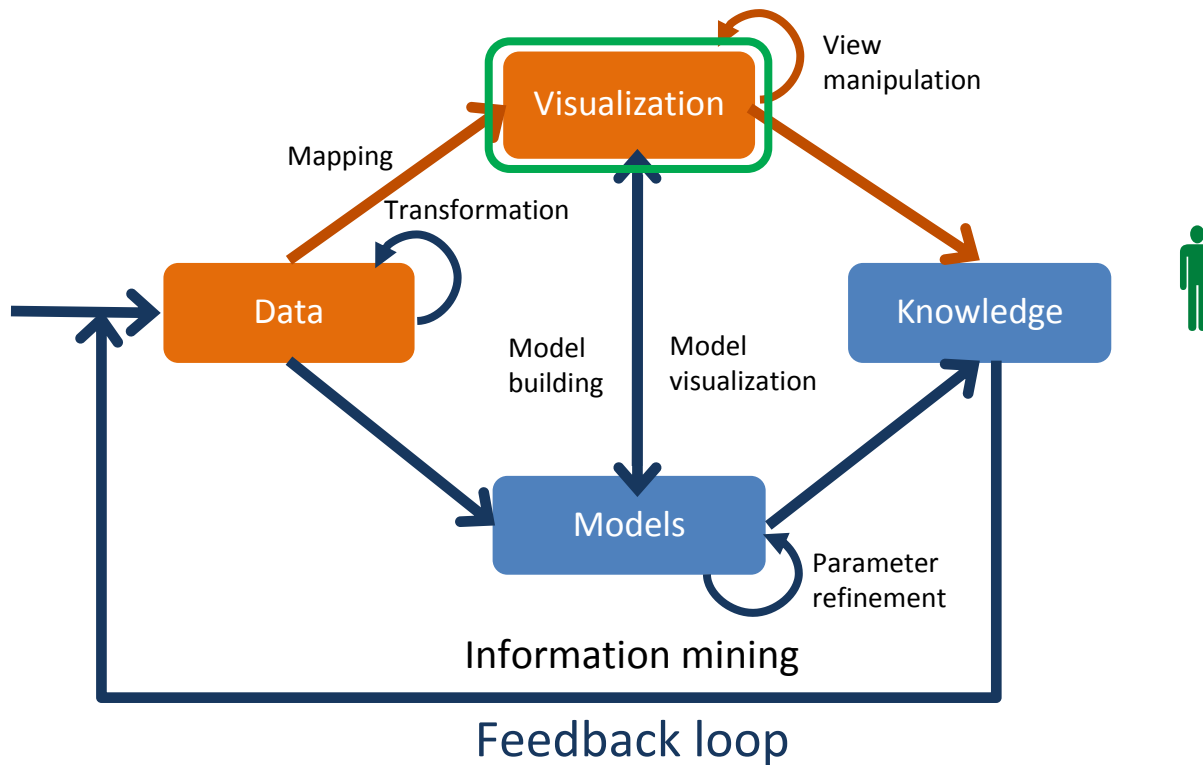
Pipeline-Focused Interaction Systematization



Unified VA Interaction Systematization



[von Landesberger et al. 2014]



3 Ways of Visual Analytics: InfoVis (Way 1)

INFOVIS – FOCUSED SYSTEMATIZATIONS

1. Visualization Systematizations

[Shneiderman 96]

1. Information Visualization

[Keim02] [Parsons & Sedig 14]

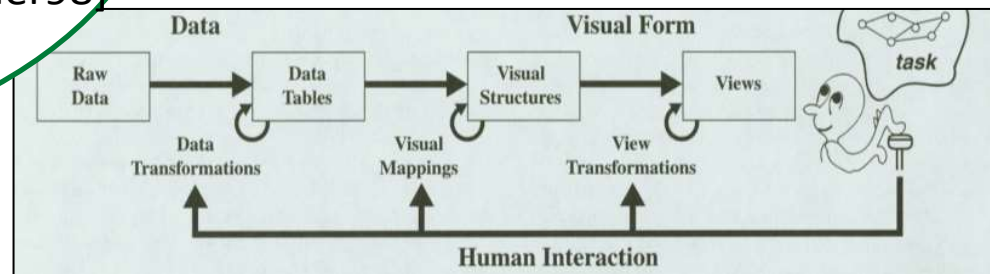
[Pike et al 09] [Dix & Ellis98] [Spence07]
[Yi et al. 07]

[Roth13] **[Wybrow et al 14]**

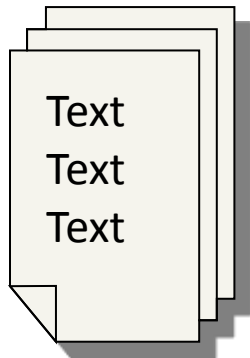
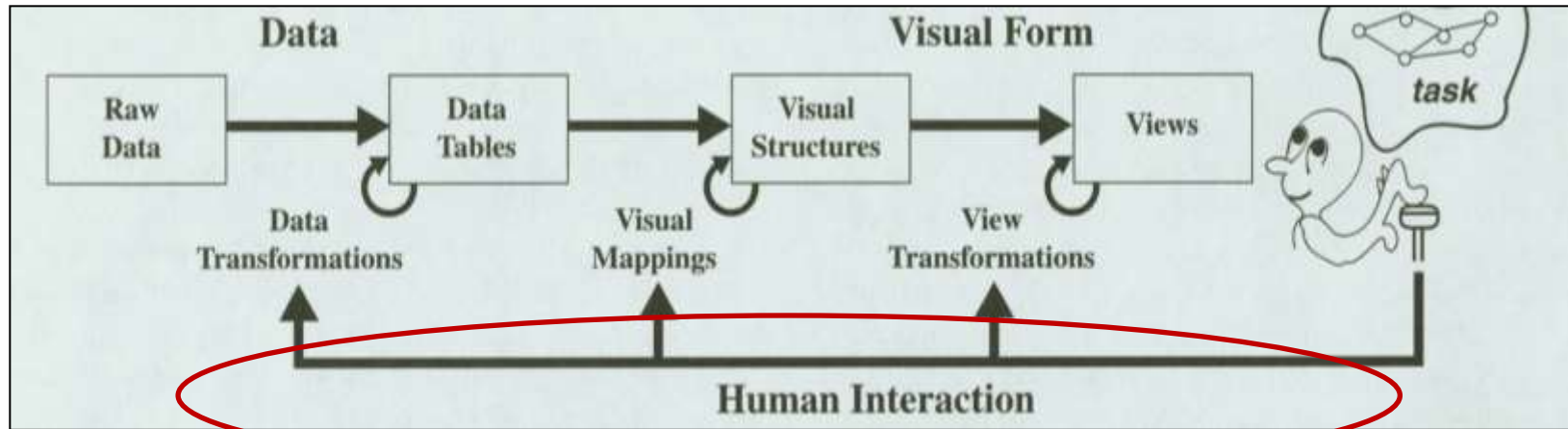
[Jansen, Dragicevic 13] [Zhou & Fesner98]

[...]

Infovis pipeline based systematization



1. Visualization Systematization



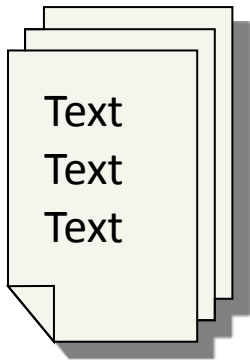
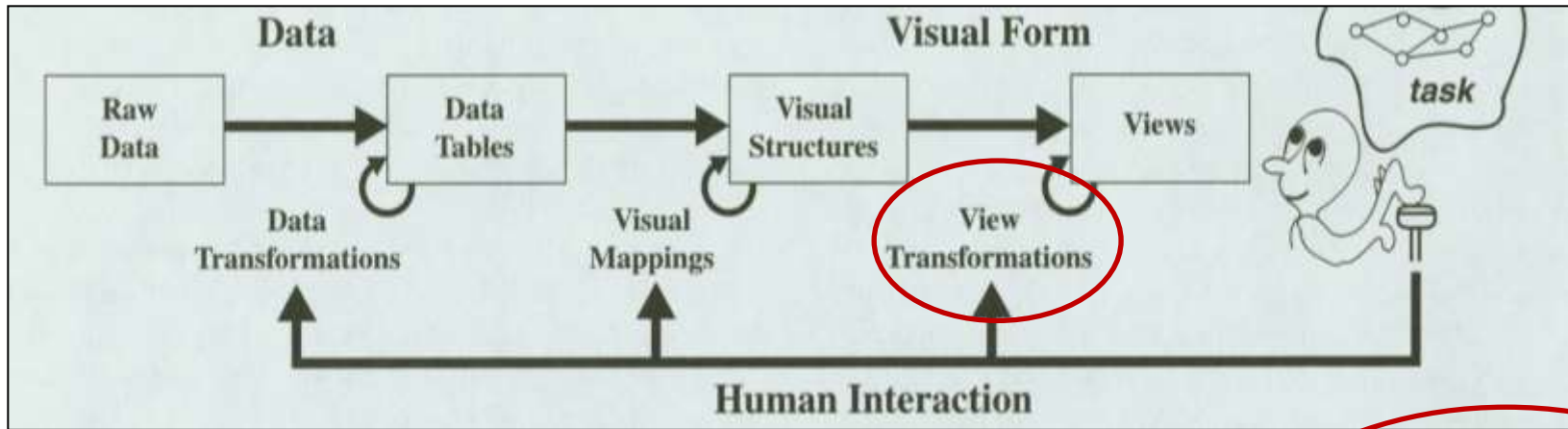
#Words	#Sentence
50	9
100	20
80	7

#Words → Size
 #Sentences → Colors



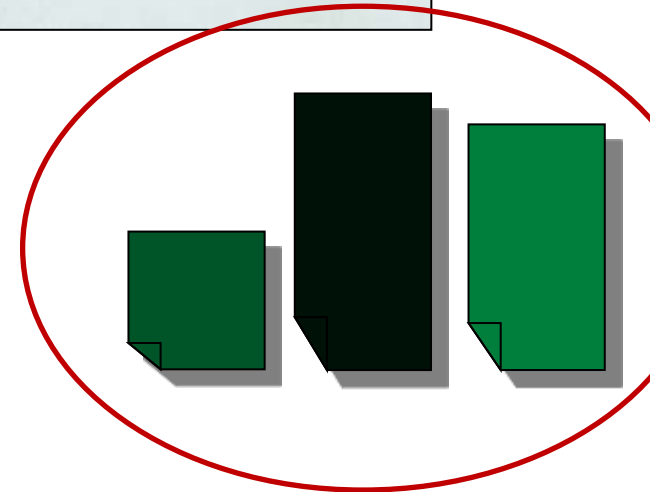
[Card et al 99]

InfoVis Interaction: View Transformation



#Words	#Sentence
50	9
100	20
80	7

#Words → Size
#Sentences → Colors



[Card et al 99]

InfoVis Interaction: View Transformation

- Navigation
- Pan, zoom, scroll,...

Navigation in visible space



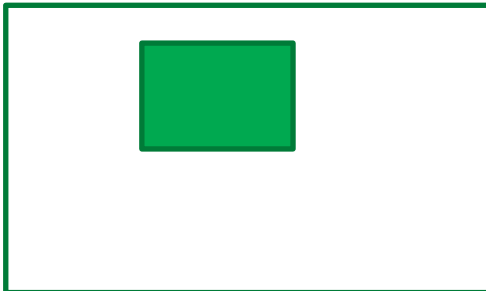
Source: maps.google.com

InfoVis Interaction: View Transformation

NAVIGATE: Paris → Sydney

- Navigation
- Pan, zoom, scroll,...

Navigation in visible space

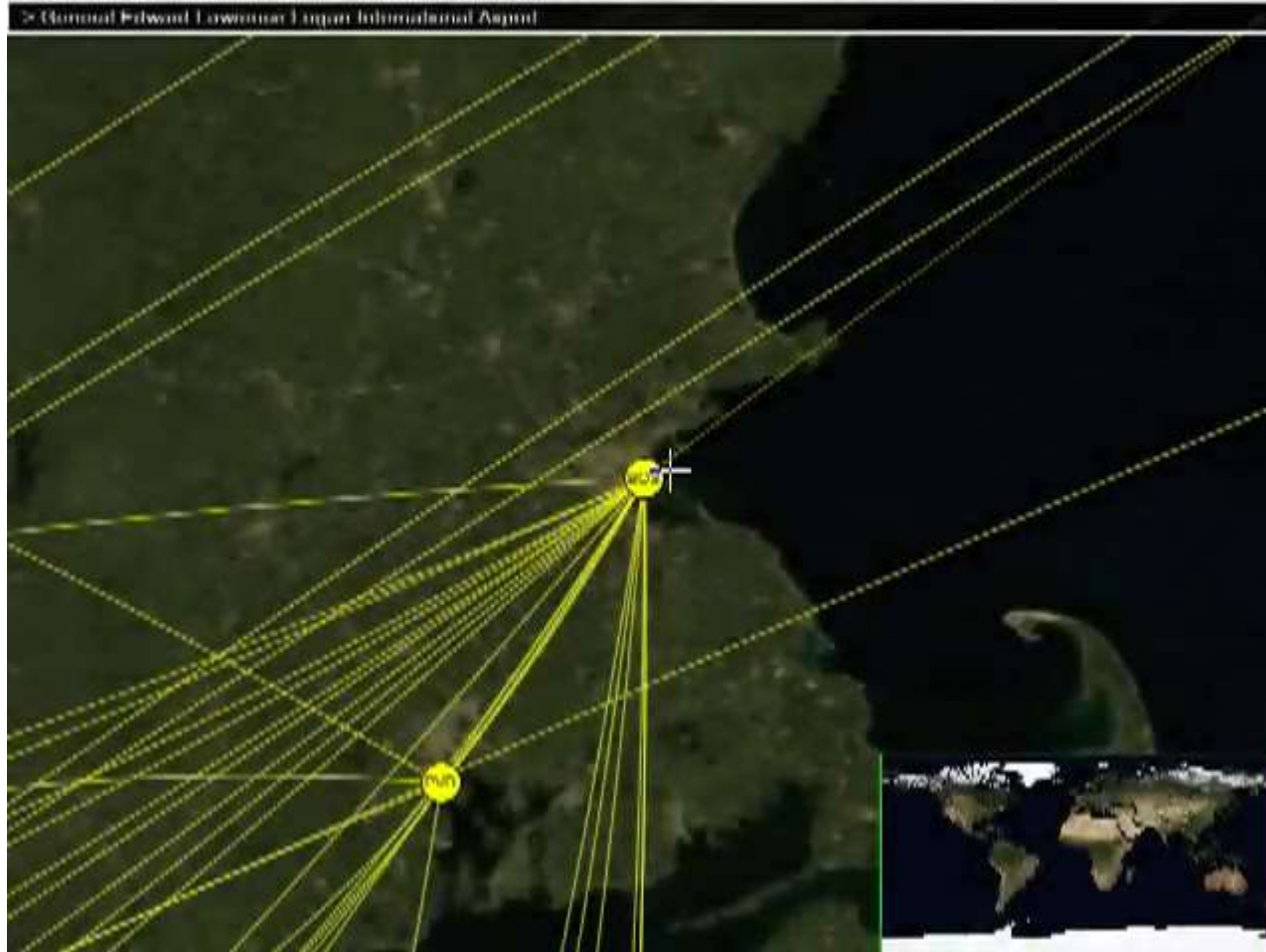


Source: maps.google.com

Problem: Cumbersome, time consuming, “lost in space”

InfoVis Interaction: View Transformation Navigation

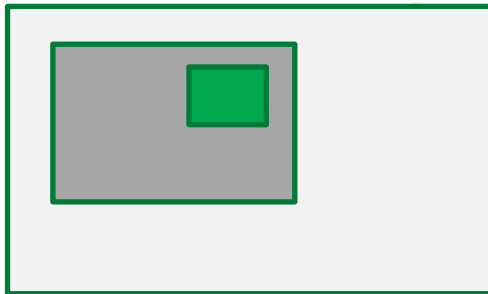
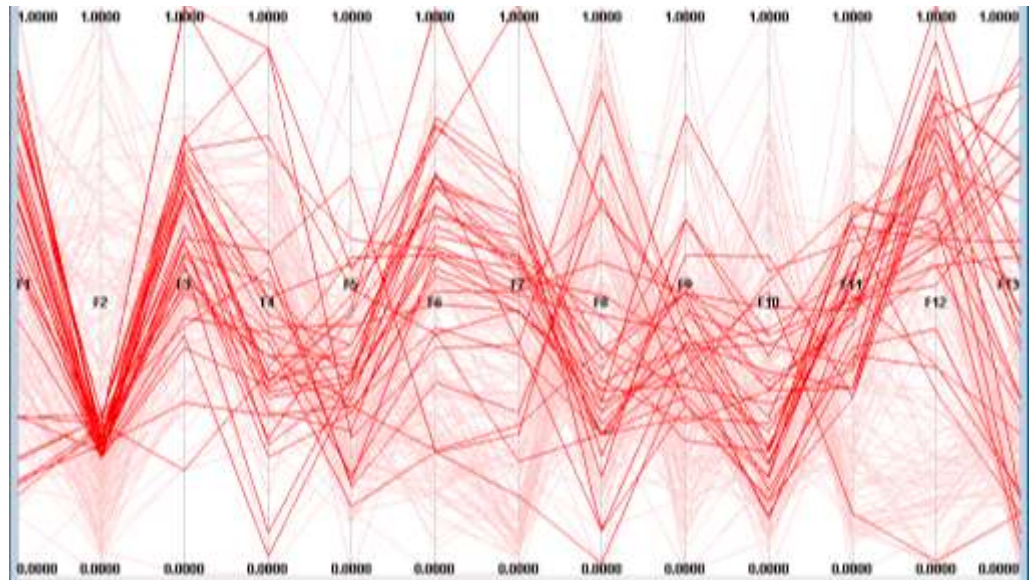
Topology-Aware Navigation in Large Networks



[Moskovich et al.09]

InfoVis Interaction: View Transformation

- Navigation
 - Pan, zoom, scroll,...
- Highlighting
 - Hover
 - Select+highlight
 - Brushing and linking
 - Magic lenses



ation

multiple views on the screen

s

Highlighting important information

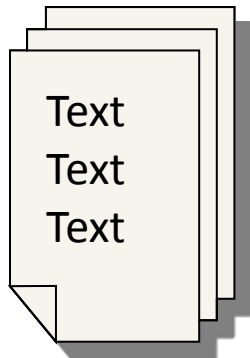
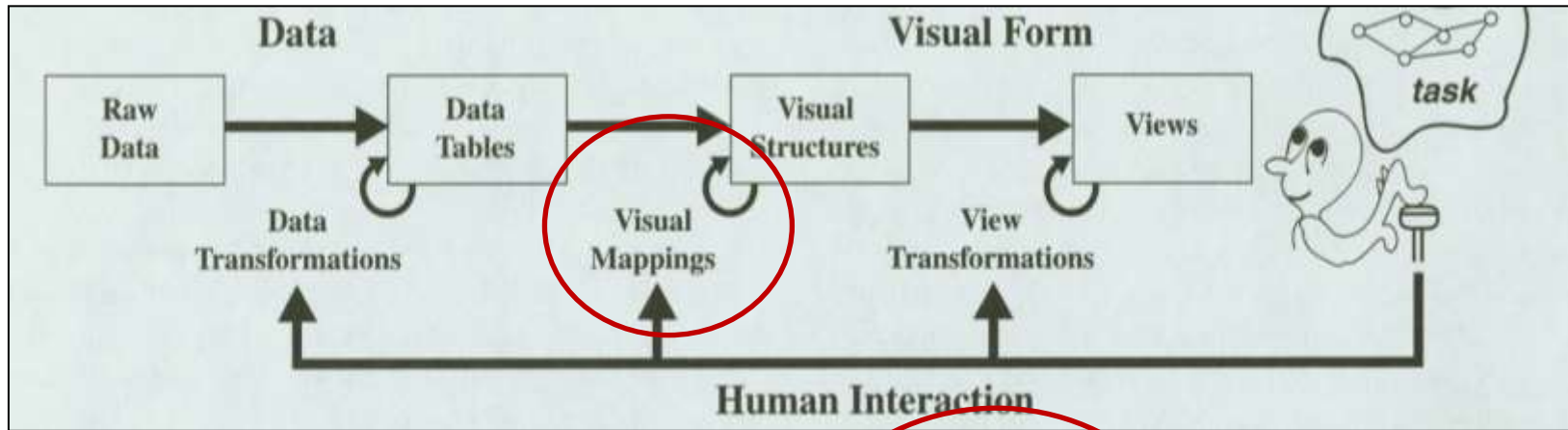
InfoVis Interaction: View Transformation

- Navigation
 - Pan, zoom, scroll,...
- Highlighting
 - Hover
 - Select+highlight
 - Brushing and linking
 - Magic lenses
- View reconfiguration
 - (Re-)arrange multiple views on the screen
 - Open/close new views



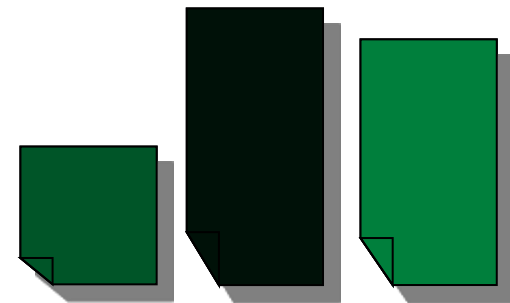
Configuring multiple views

InfoVis Interaction: Visual Mapping



#Words	#Sentence
50	9
100	20
80	7

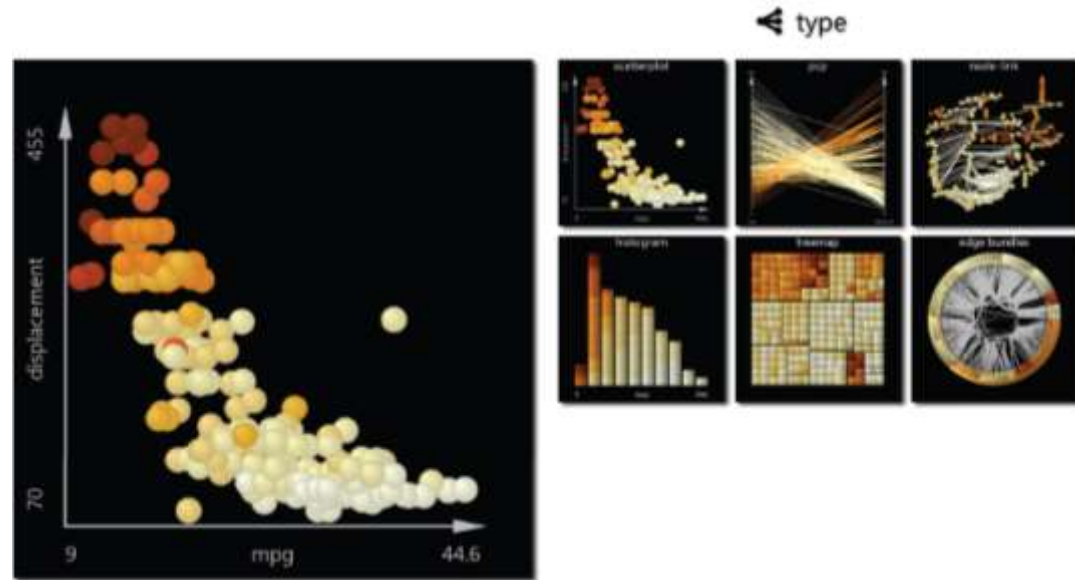
#Words → Size
 #Sentences → Color



[Card et al 99]

InfoVis Interaction: Visual Mapping

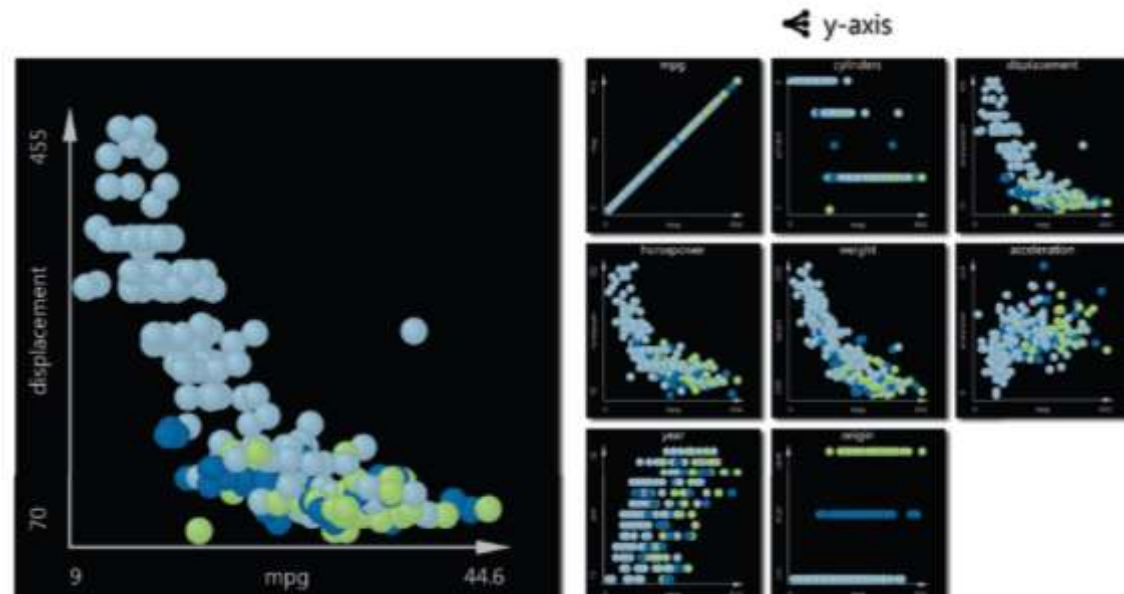
- Visualization type
 - Type of visualization
 - Scatterplot/matrix
 - Node-link/matrix
 - Type of mapping
 - E.g. color/size/form



[van den Elzen & van Wijk 13]

InfoVis Interaction: Visual Mapping

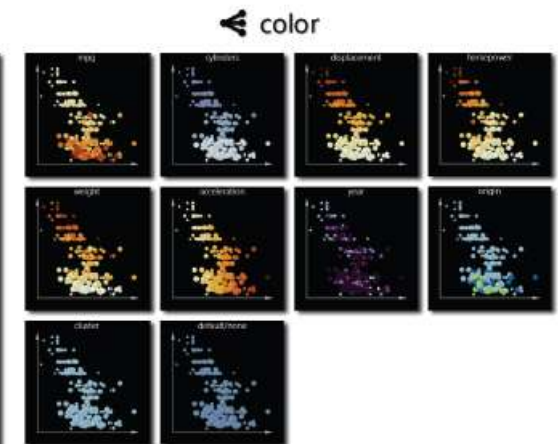
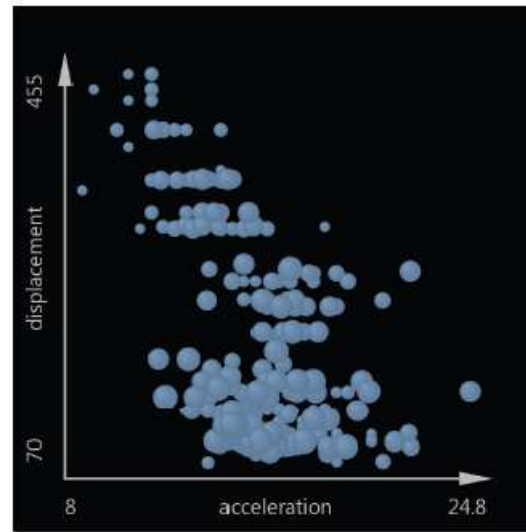
- Visualization type
- Type of visualization
- Type of mapping
- Mapping parameter
- Data \leftrightarrow mapping
- E.g. color scheme



[van den Elzen & van Wijk 13]

InfoVis Interaction: Visual Mapping

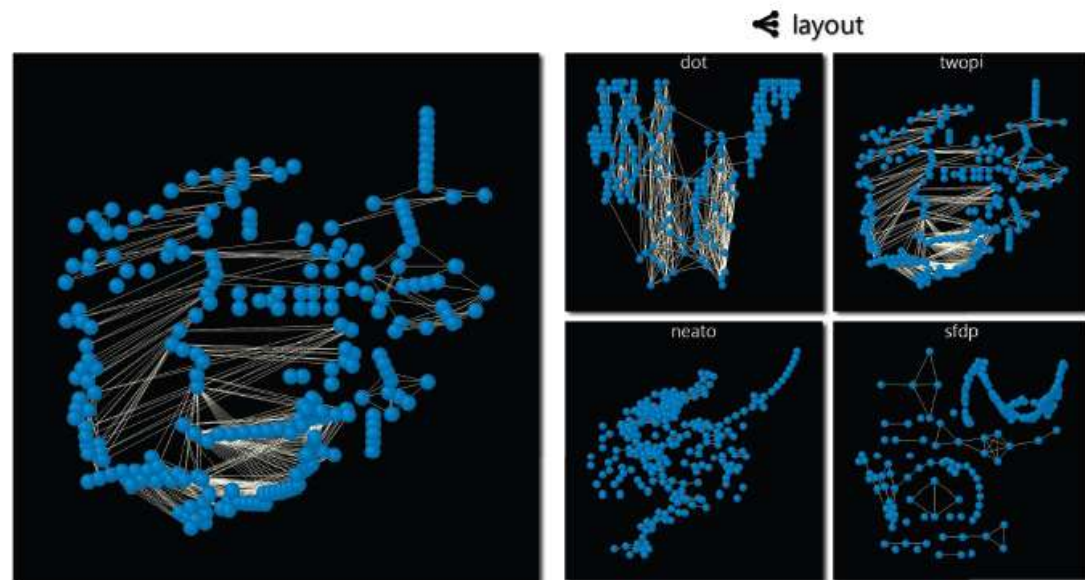
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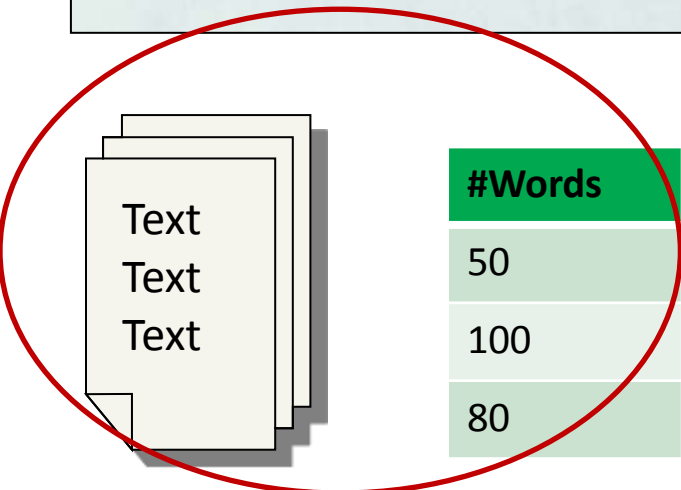
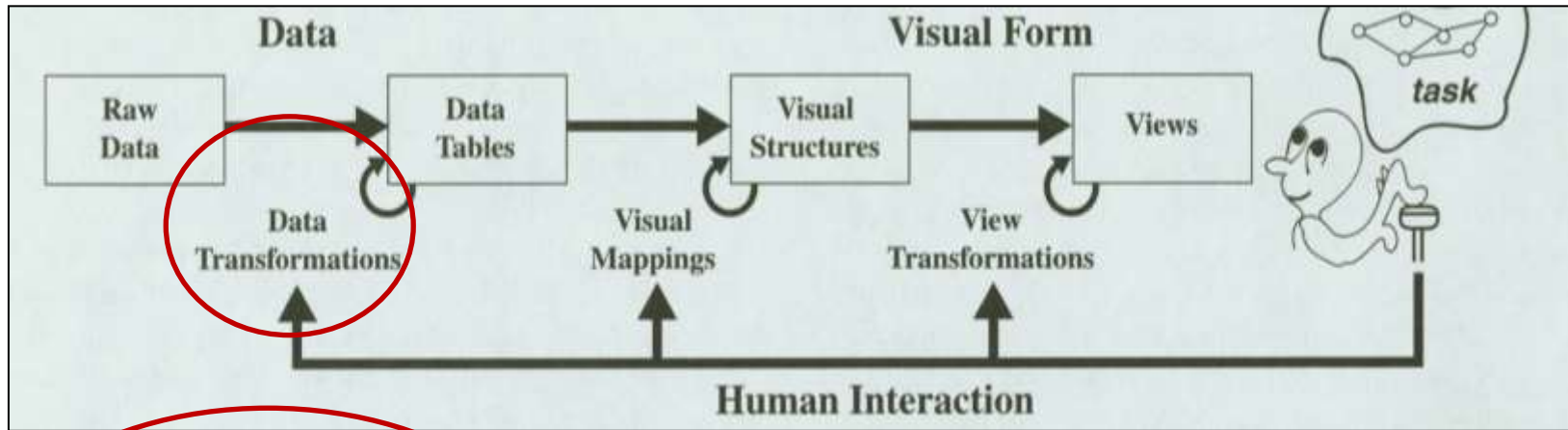
InfoVis Interaction: Visual Mapping

- Visualization type
 - Type of visualization
 - Type of mapping
- Mapping parameter
 - Data to be mapped
 - E.g. color scheme
- Further specifics
 - E.g. type of layout, sorting

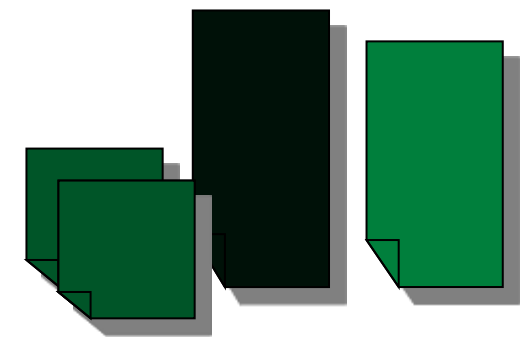


[van den Elzen & van Wijk 13]

InfoVis Interaction: Data Manipulation



#Words → Size
 #Sentences → Color



[Card et al 99]

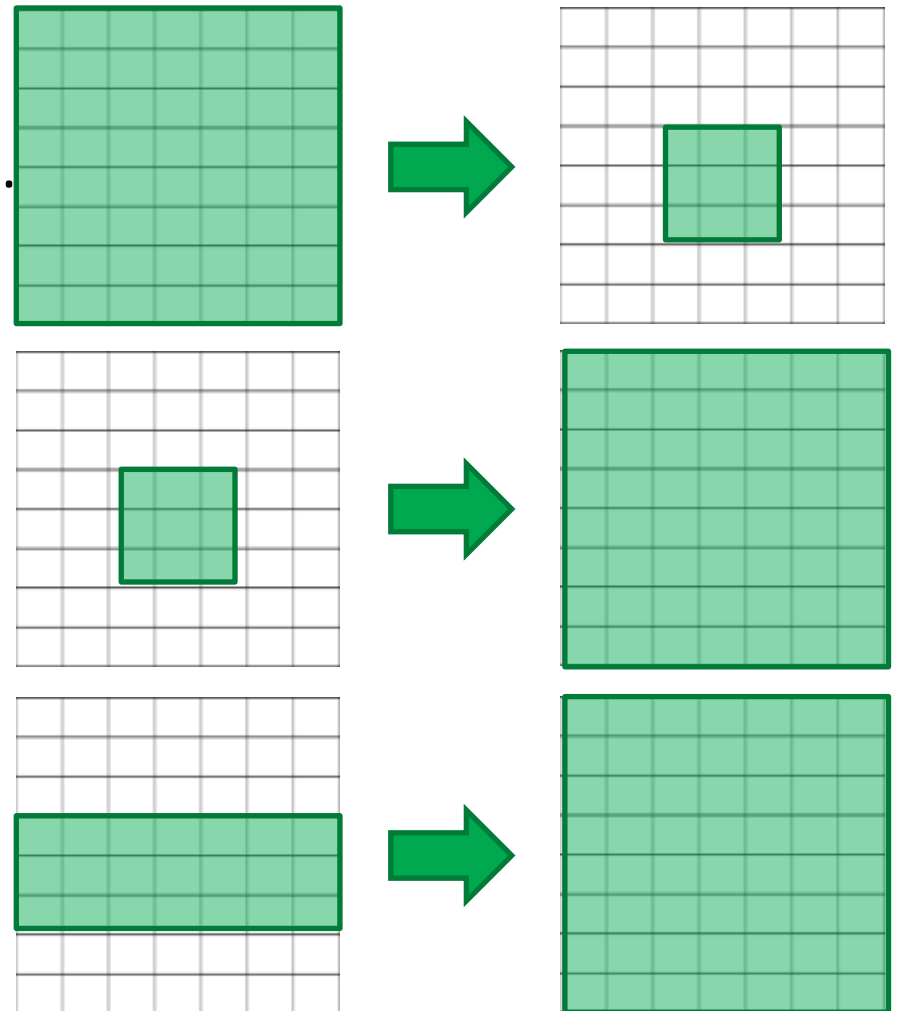
InfoVis Interaction: Data Manipulation

- Data navigation
 - drill down, expand, filter, ...

InfoVis Interaction: Data Manipulation

- Data navigation
 - drill down, expand, filter, ...
 - Top down
 - Filter, details on demand
 - Bottom up
 - Expand on demand
 - Middle out
 - Start in the middle

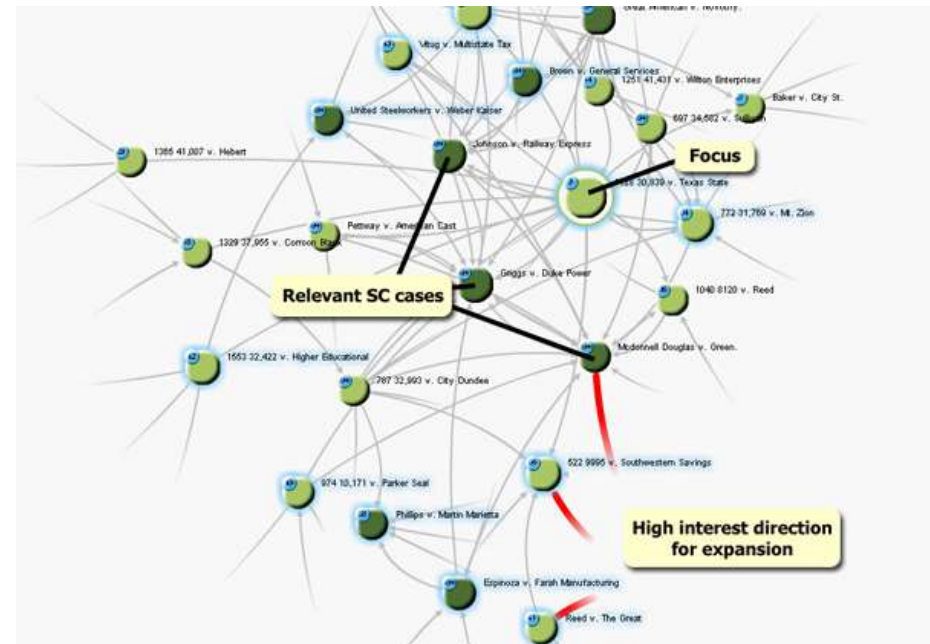
[von Landesberger et al 11]



InfoVis Interaction: Data Manipulation

- Data navigation
 - drill down, expand, filter, ...
- Top down
- Filter, details on demand
- Bottom up
- **Expand on demand**
- Middle out
- Start in the middle

Search, Show Context, Expand on Demand



[van Ham & Perer 09]

InfoVis Interaction: Data Manipulation

Data selection
for visualization

InfoVis Interaction: Data Manipulation

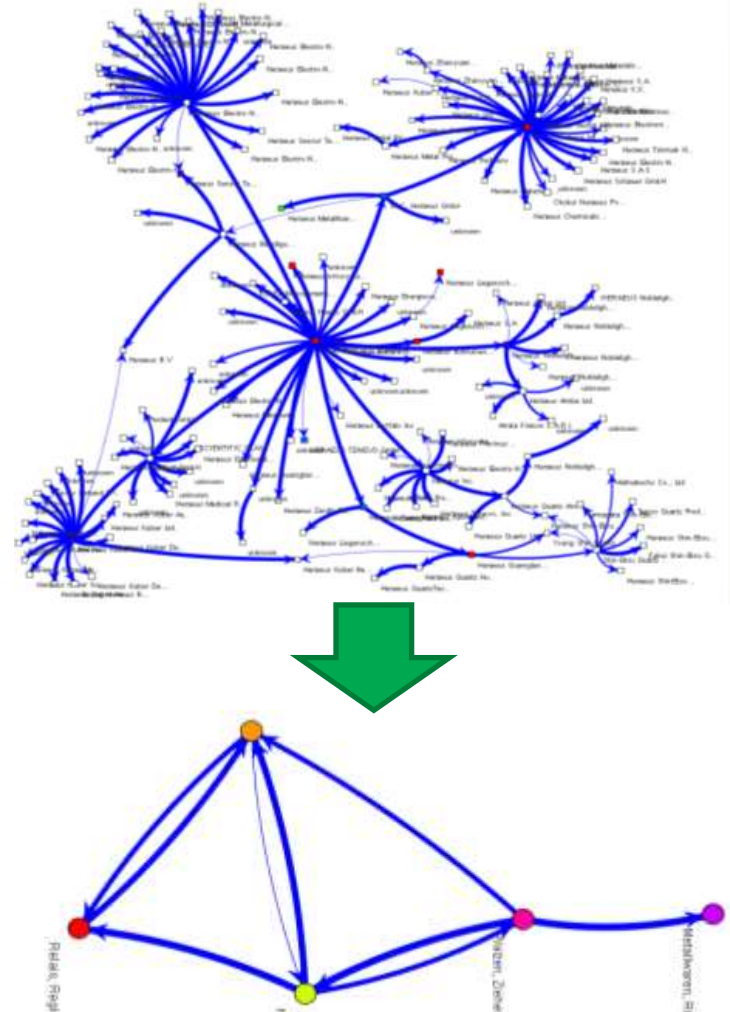
- Data navigation
 - drill down, expand, filter, ...
- Data transformation
 - Normalization (lin, log, exp,...)
 - Aggregation (manual, according to data,...)
 - ...



Source: Gapminder.org

InfoVis Interaction: Data Manipulation

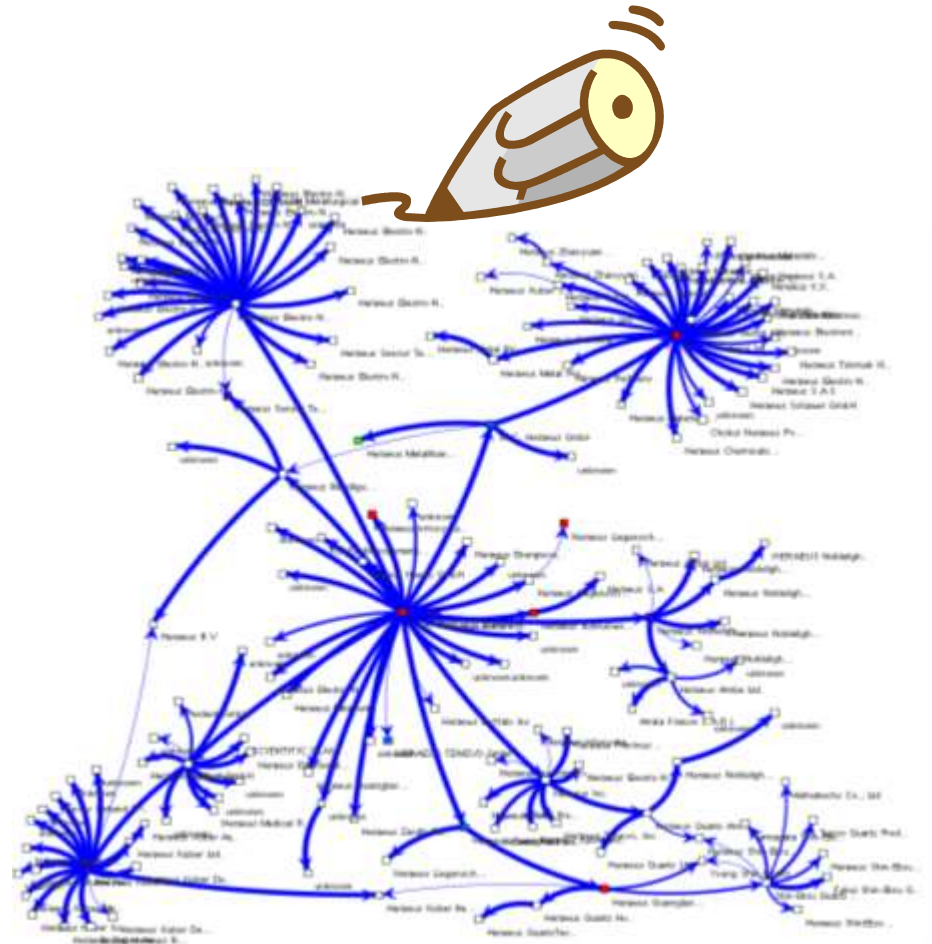
- Data navigation
 - drill down, expand, filter, ...
- Data transformation
 - Normalization (e.g. lin, log)
 - Aggregation
 - Manual
 - According to data attributes
 - According to data structure (e.g. communities)
 - Etc.



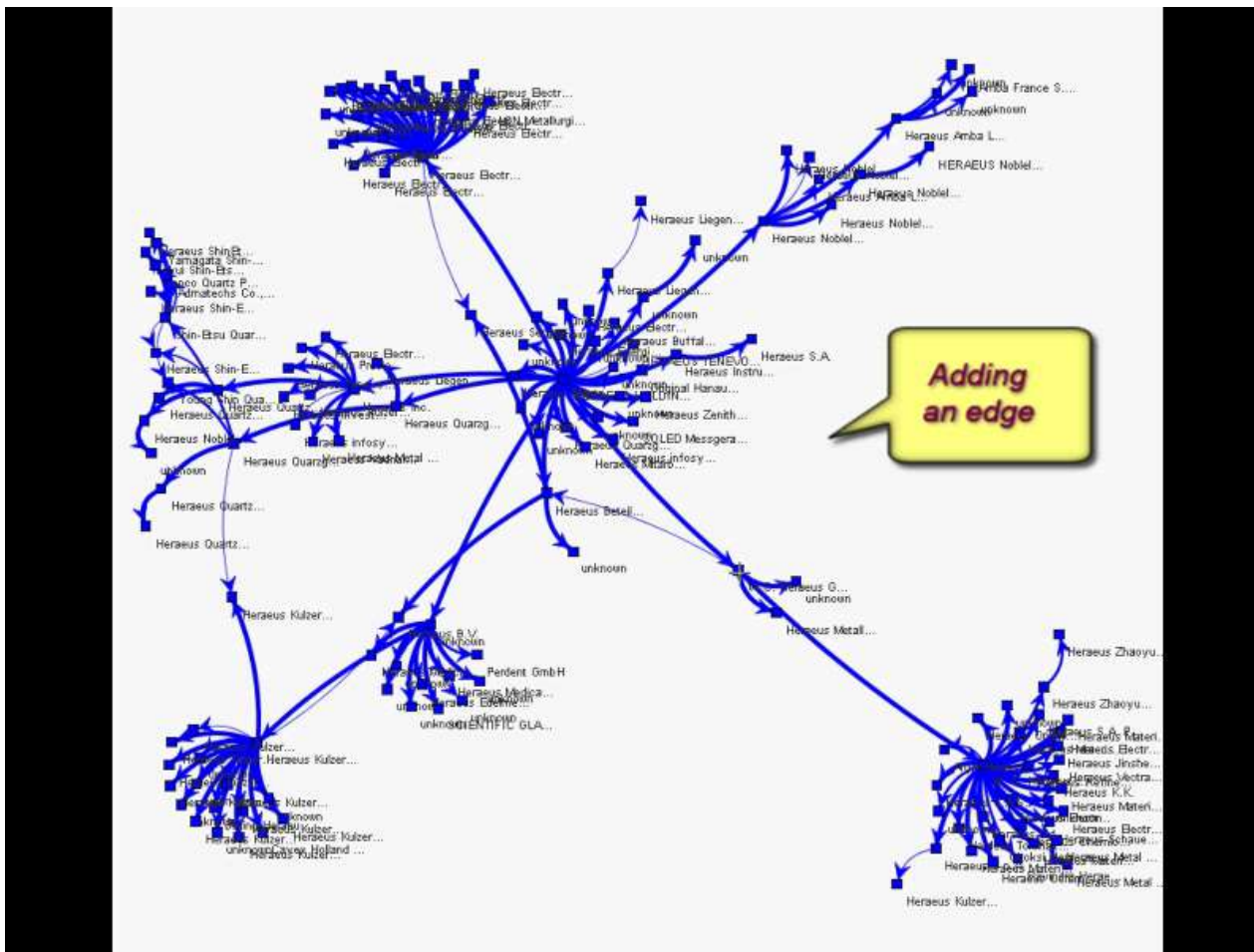
2. Graph simplification by structure

InfoVis Interaction: Data Manipulation

- Data navigation
 - drill down, expand, filter, ...
- Data transformation
 - Normalization (lin, log, exp,...)
 - Aggregation (manual, according to data,...)
- Data editing
 - Change values
 - Create data
 - Individual values
 - Whole datasets



InfoVis Interaction: Data editing

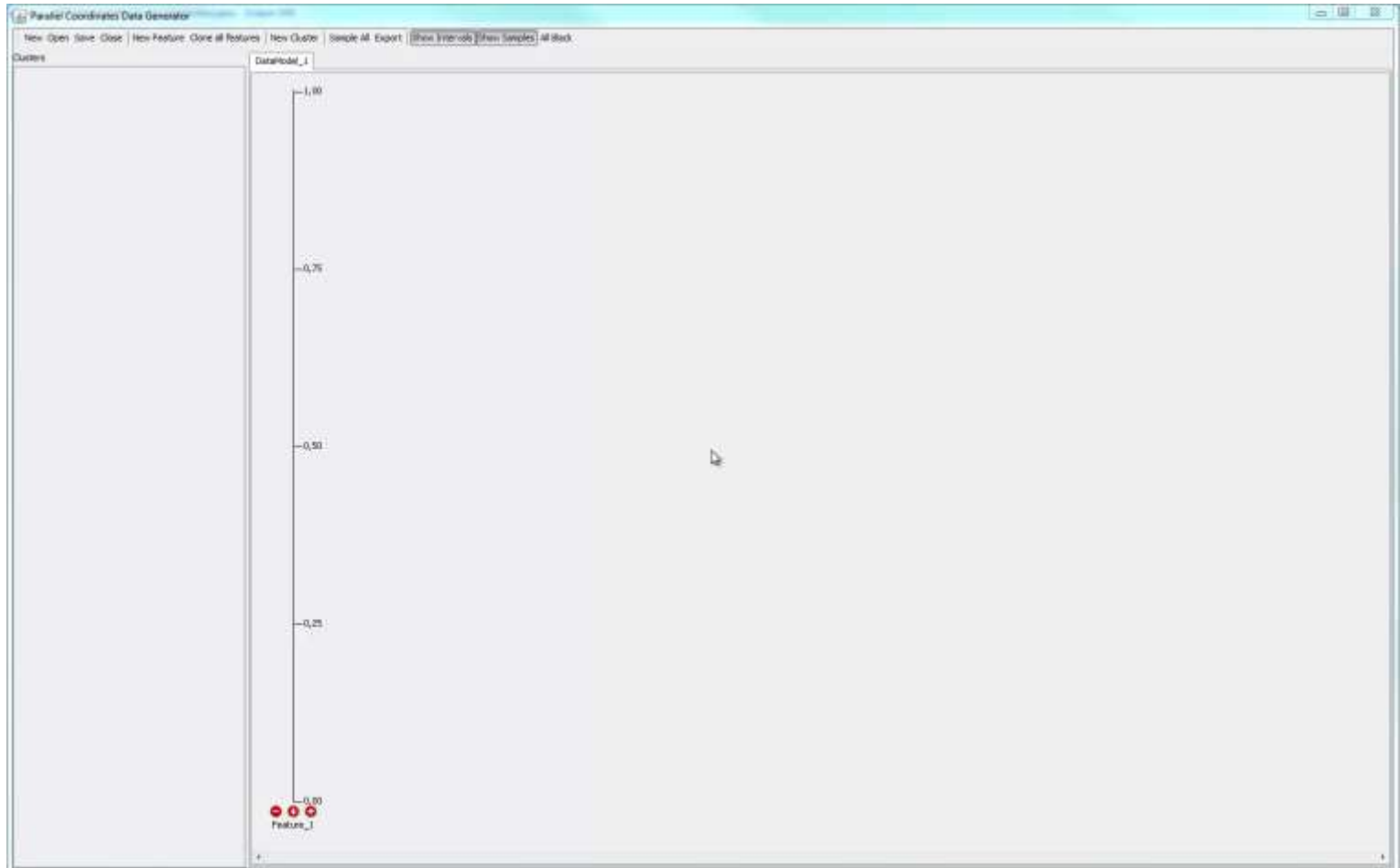


PC/DC

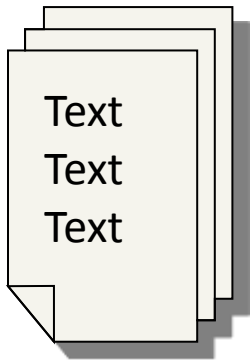
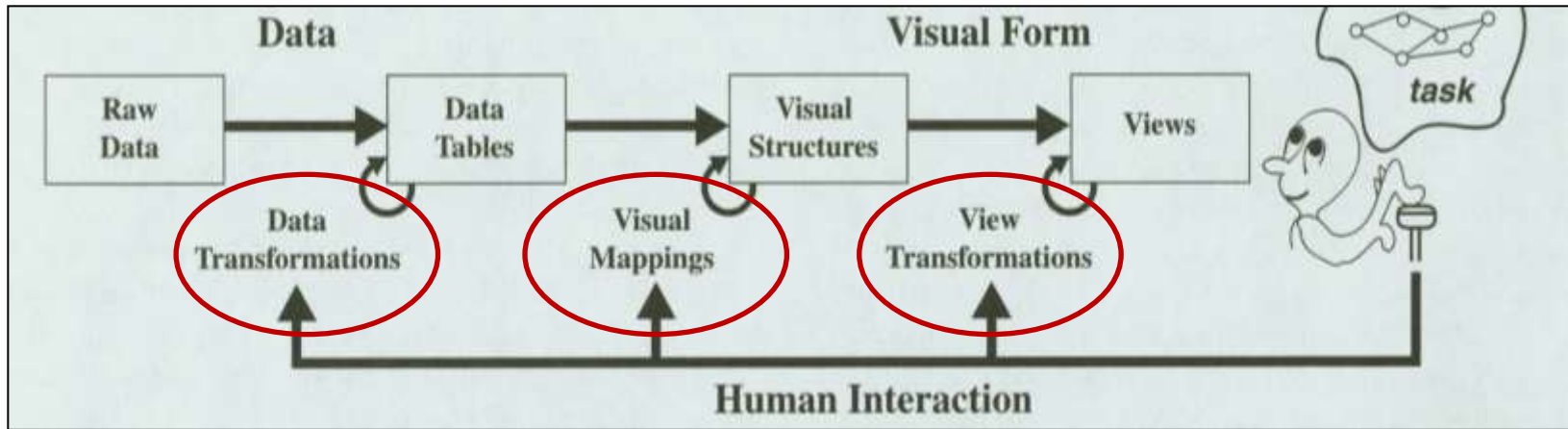
InfoVis Interaction: Data creation

On the Highway to Data

[Bremm et al 2012]



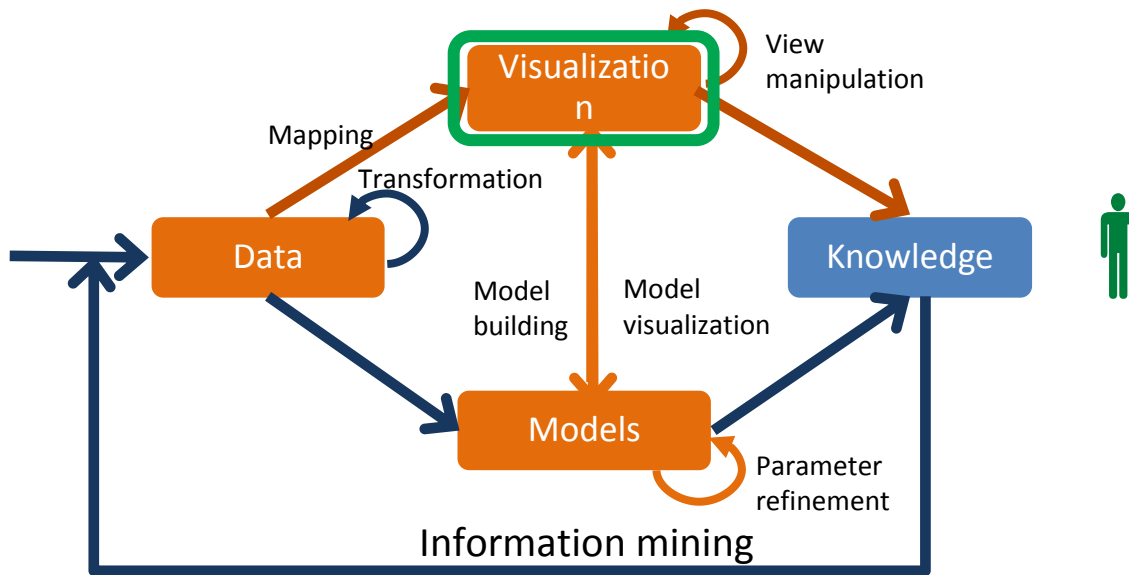
Summary: InfoVis Interaction



#Words	#Sentence
50	9
100	20
80	7

#Words → Size
#Sentences → Colors





Way 2: Visual data mining

VISUAL DATA MINING INTERACTION

VA Interaction Systematization

2. Visual Data Mining

[Bertini & Lalanne 09]

[...]

1. Information Visualization

Visual Data Mining

- Computationally enhanced Visualization (V++)
- Visually enhanced Mining (M++)
- Integrated Visualization and Mining (VM)

[Bertini & Lalanne09]

Visual Data Mining Interaction

- Manipulating and tuning:

Vis:

changing representation
parameters

DM:

changing model parameters

- Changing the scheme:

Vis:

changing the visual mapping
or visual representation

DM:

changing the data model

[Bertini & Lalanne09]

Visual Data Mining Interaction

- Manipulating and tuning:

Vis:

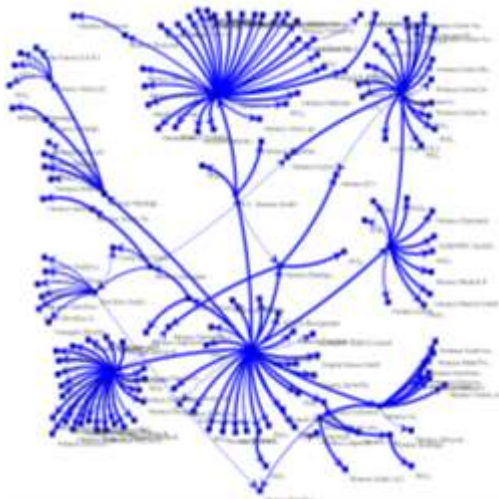
changing representation parameters

DM:

changing model parameters

For example: changing color scheme

For example which motif is searched



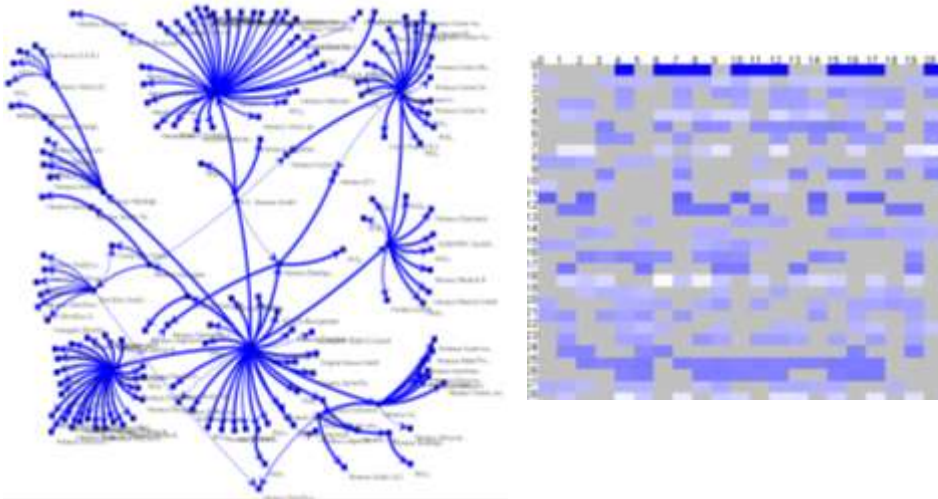
Visual Data Mining Interaction

- Changing the scheme :

Vis:

changing the visual mapping
or visual representation

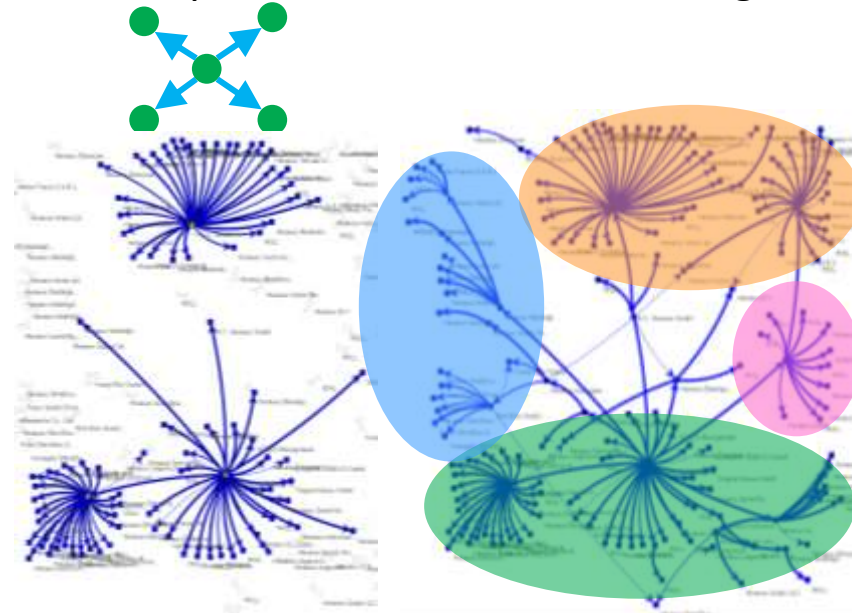
For example: changing node-link
diagram to adjacency matrix

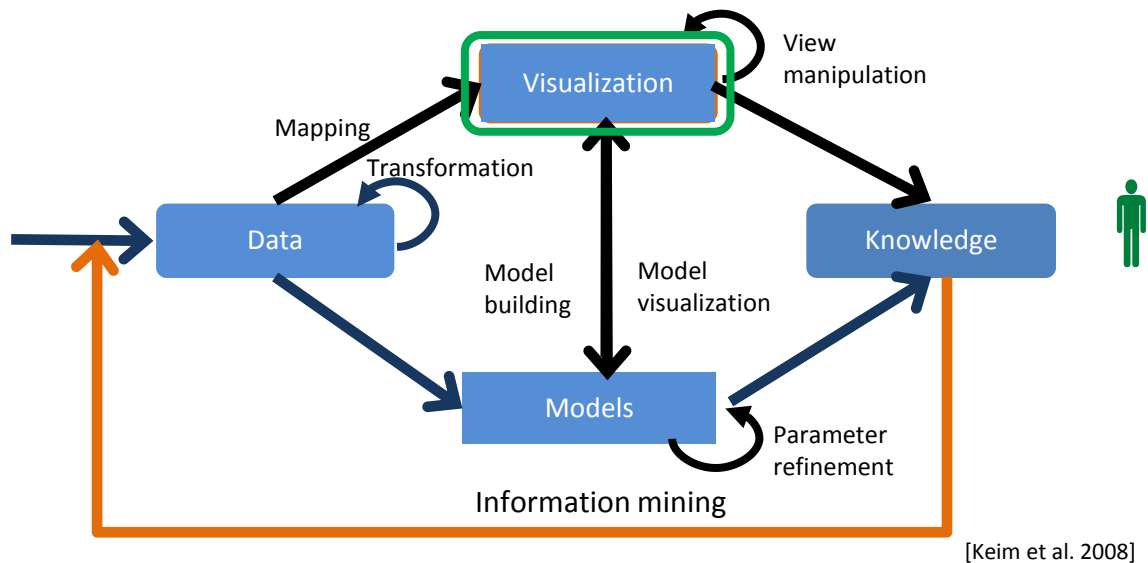


DM:

changing the data model

For example motif search vs clustering

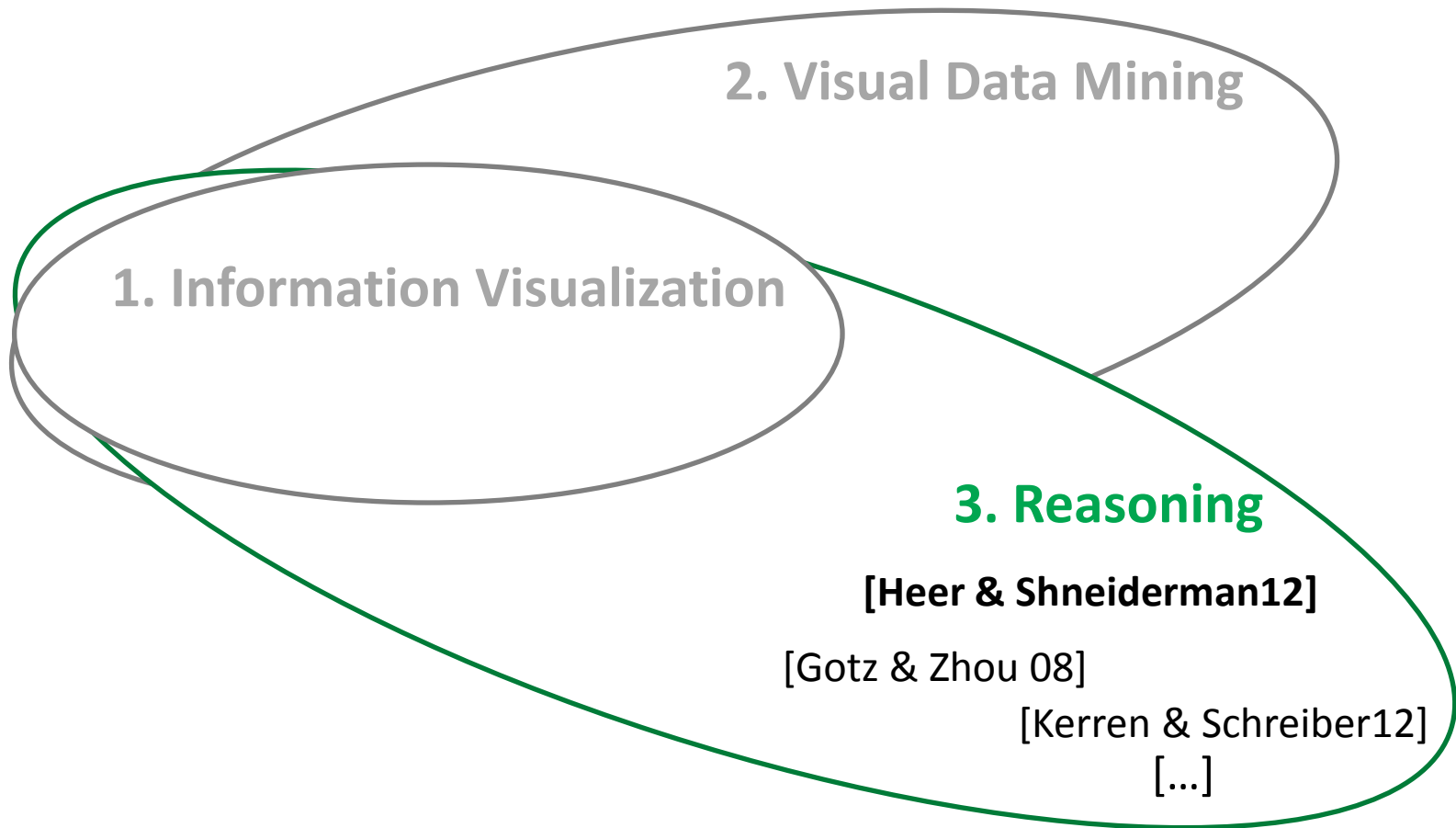




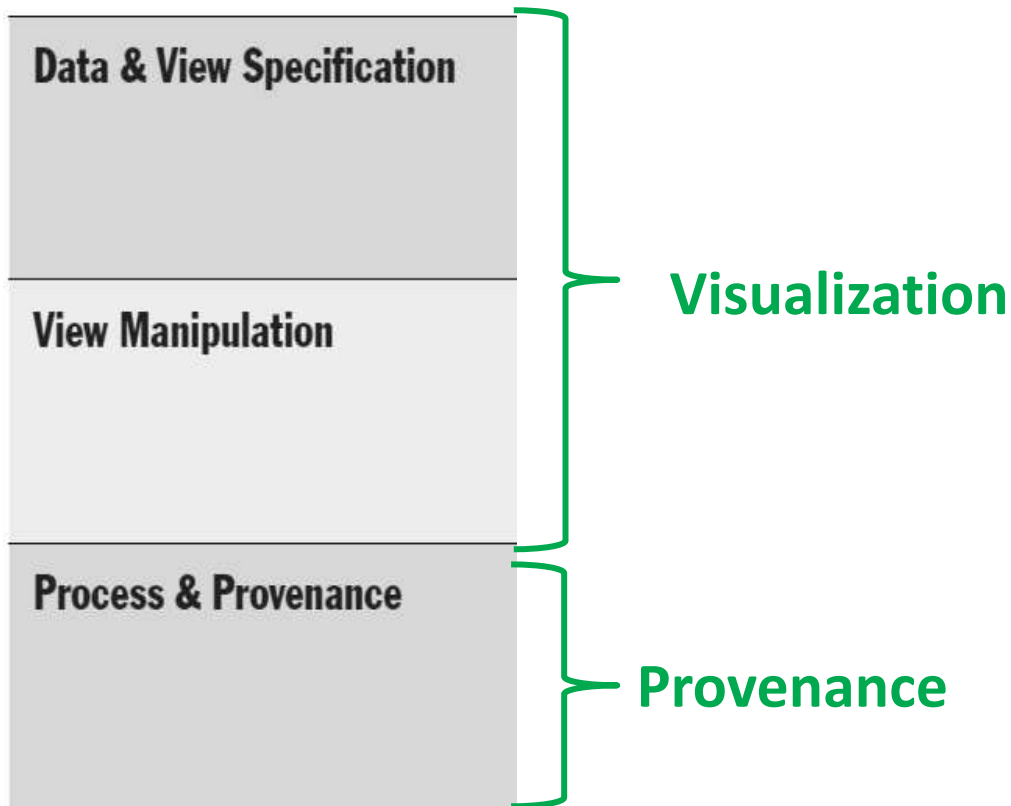
Way 3: Feedback loop

SENSEMAKING, PROVENANCE, REASONING

VA Interaction Systematization

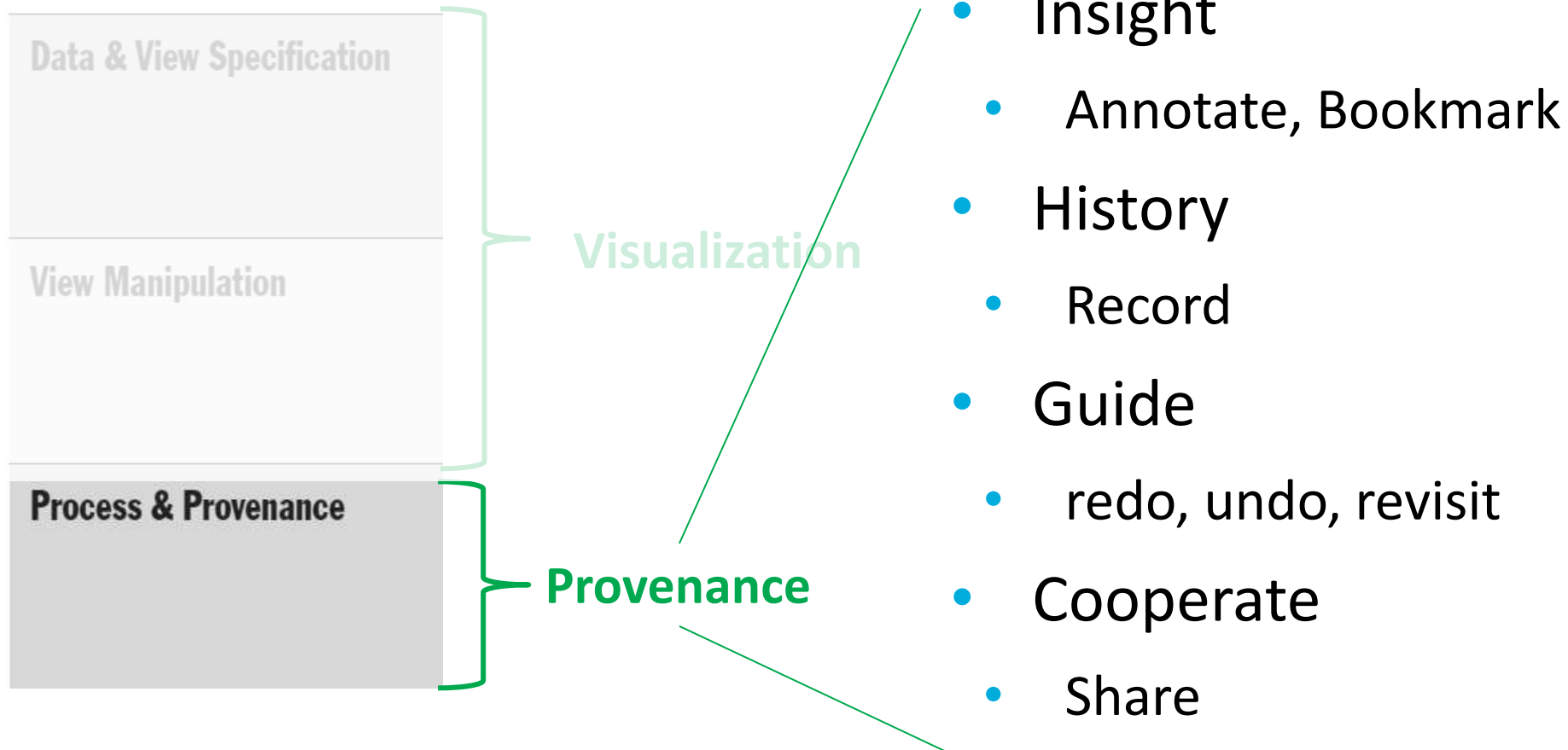


Reasoning/Provenance Systematization



[Heer & Shneiderman12]

Reasoning/Provenance Systematization

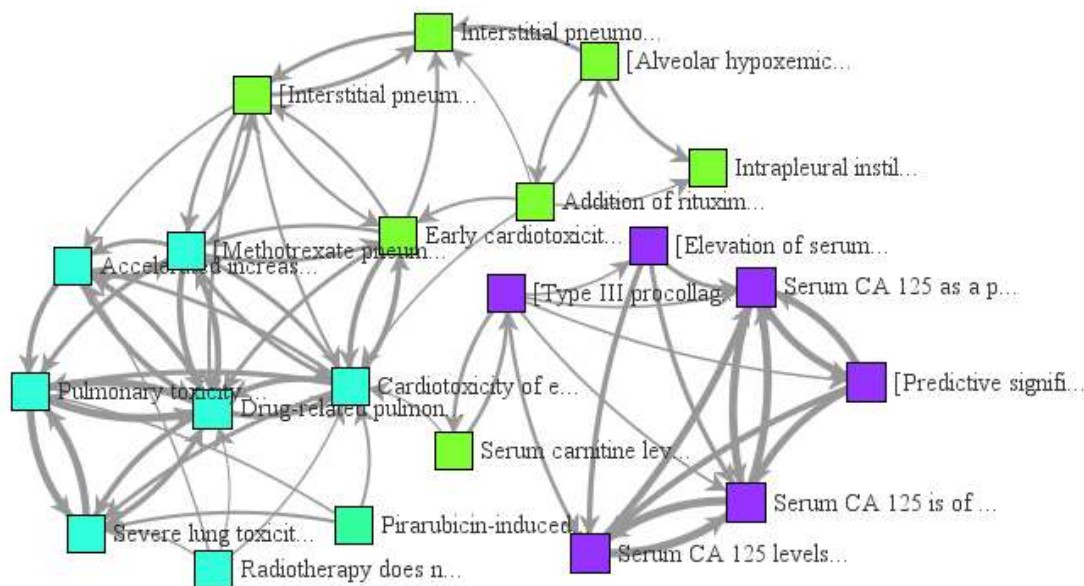


[Heer & Shneiderman12]

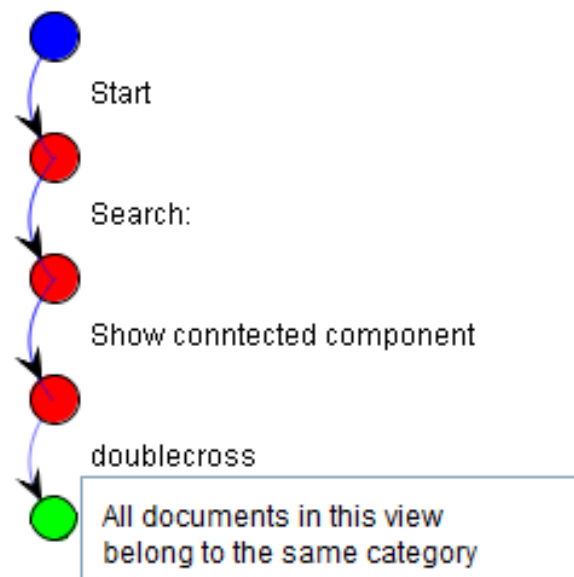
Combined
[Gotz & Zhou, Kerren et al,
Heer & Shneiderman12]

Reasoning/Provenance

Visualization



Visual history & annotation



[von Landesberger et al 14]

Reasoning/Provenance

Visualization



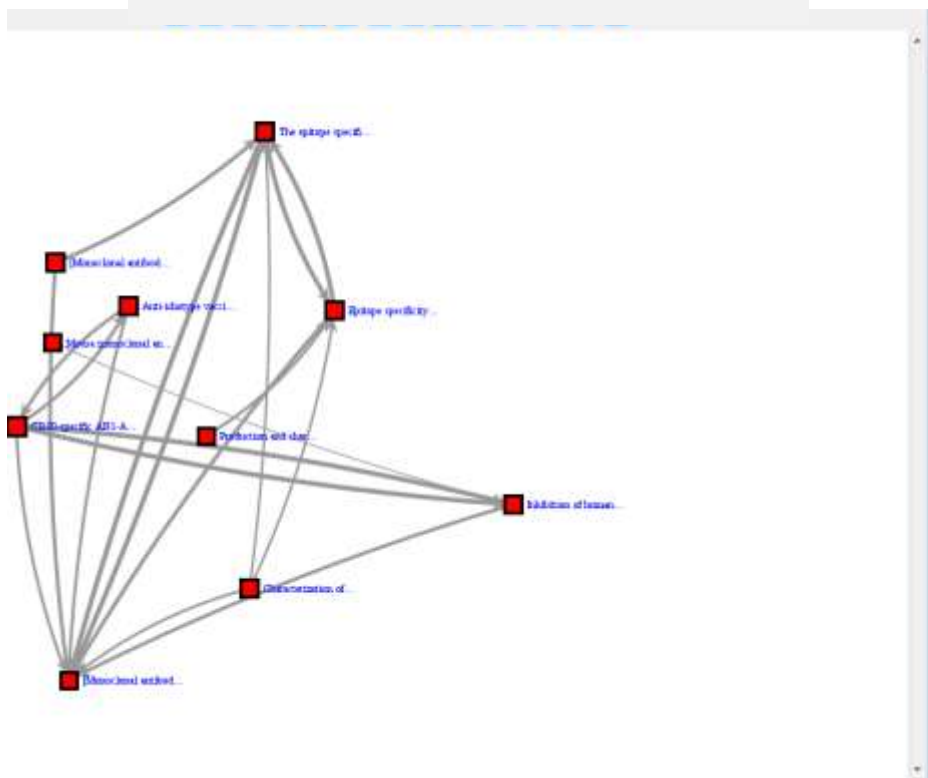
Visual history & annotation



[von Landesberger et al 14]

Reasoning/Provenance

Visualization



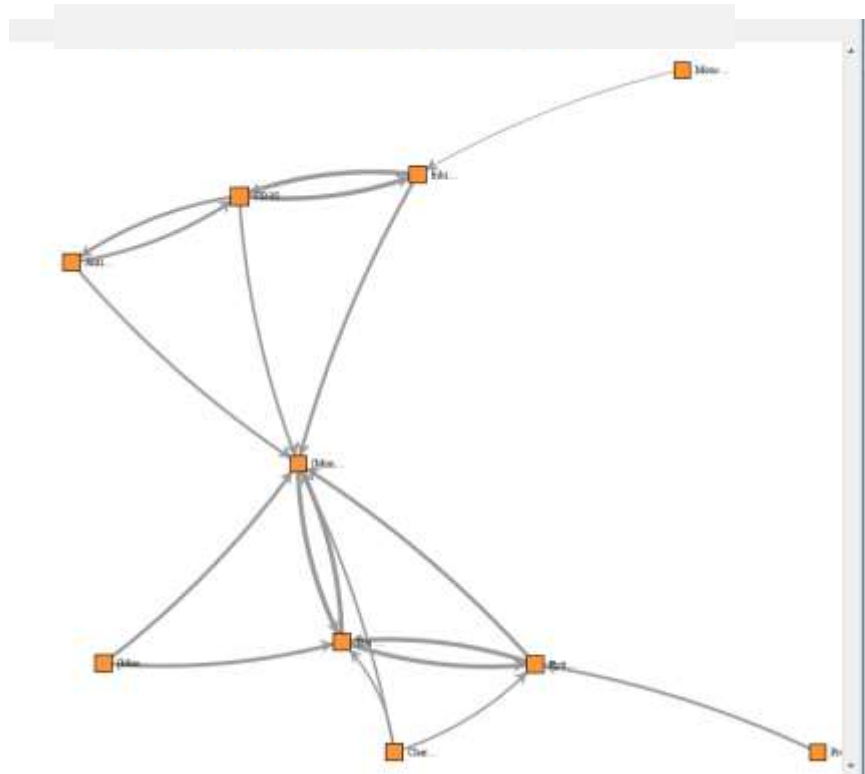
Visual history & annotation



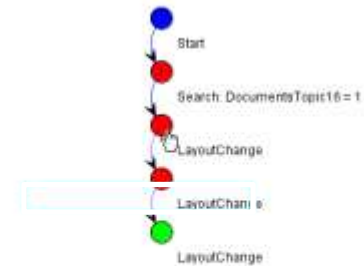
[von Landesberger et al 14]

Reasoning/Provenance

Visualization



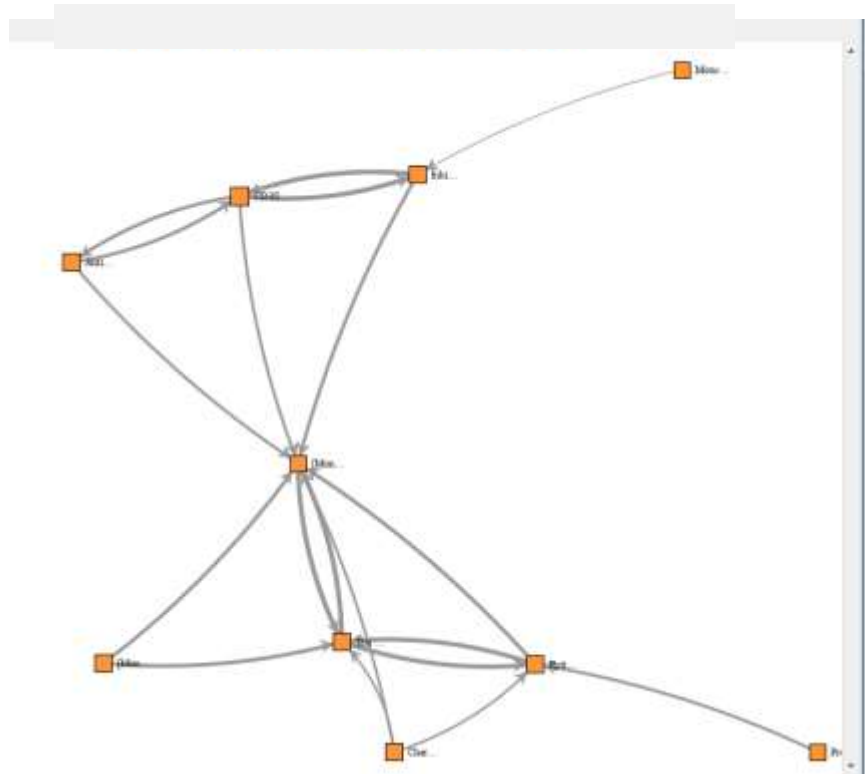
Visual history & annotation



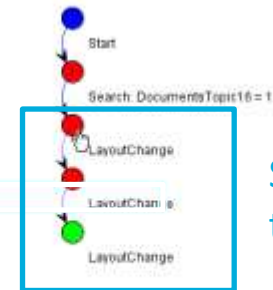
[von Landesberger et al 14]

Reasoning/Provenance

Visualization



Visual history & annotation

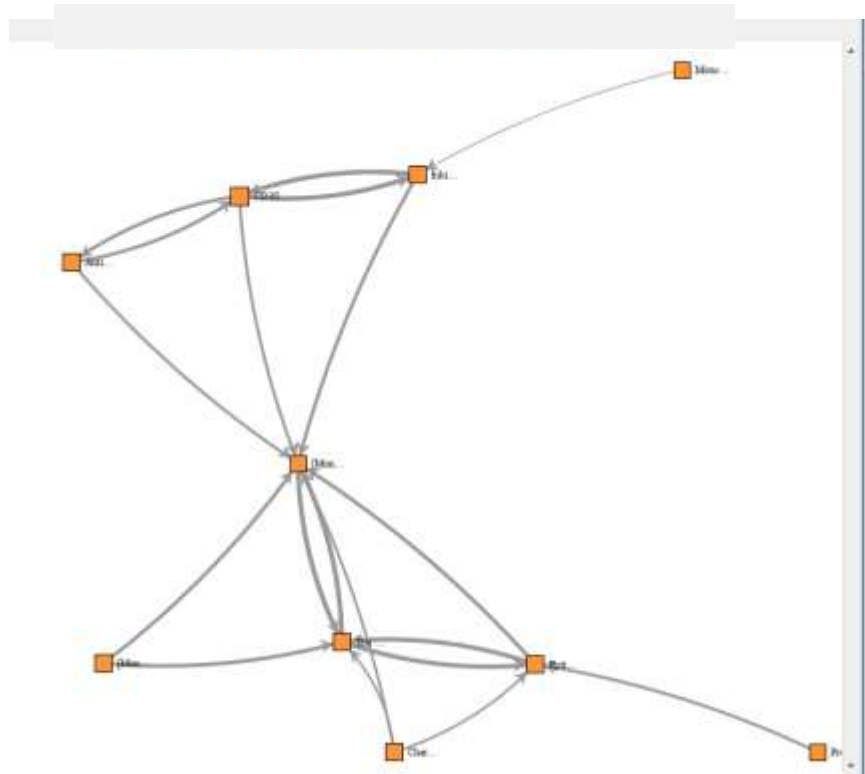


Same interaction type → aggregation

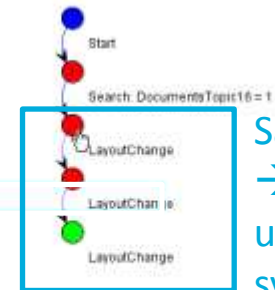
[von Landesberger et al 14]

Reasoning/Provenance

Visualization



Visual history & annotation

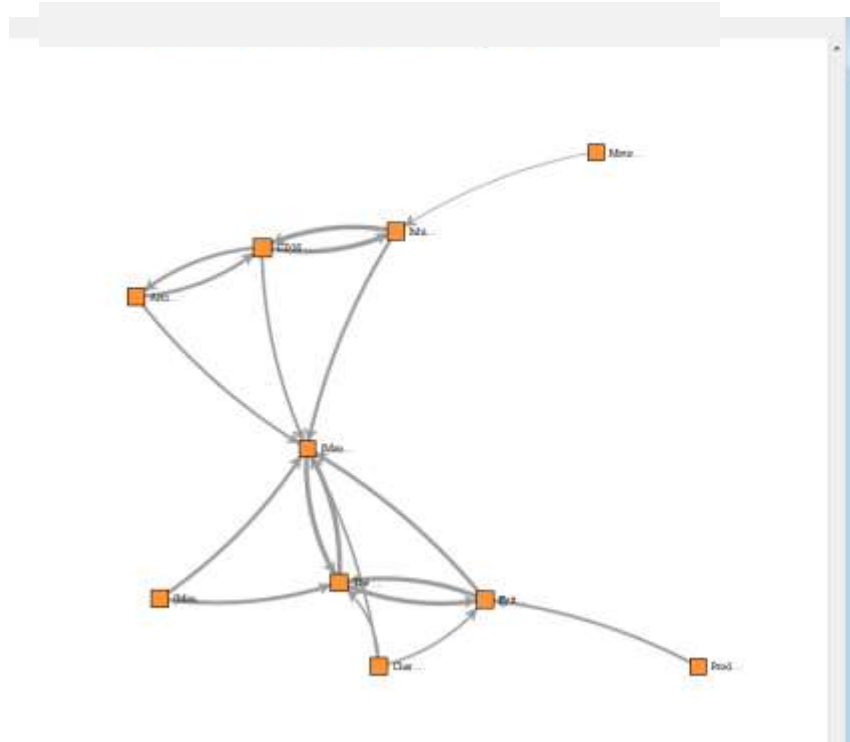


Same interaction type
→ aggregation
using interaction
systematization

[von Landesberger et al 14]

Reasoning/Provenance

Visualization



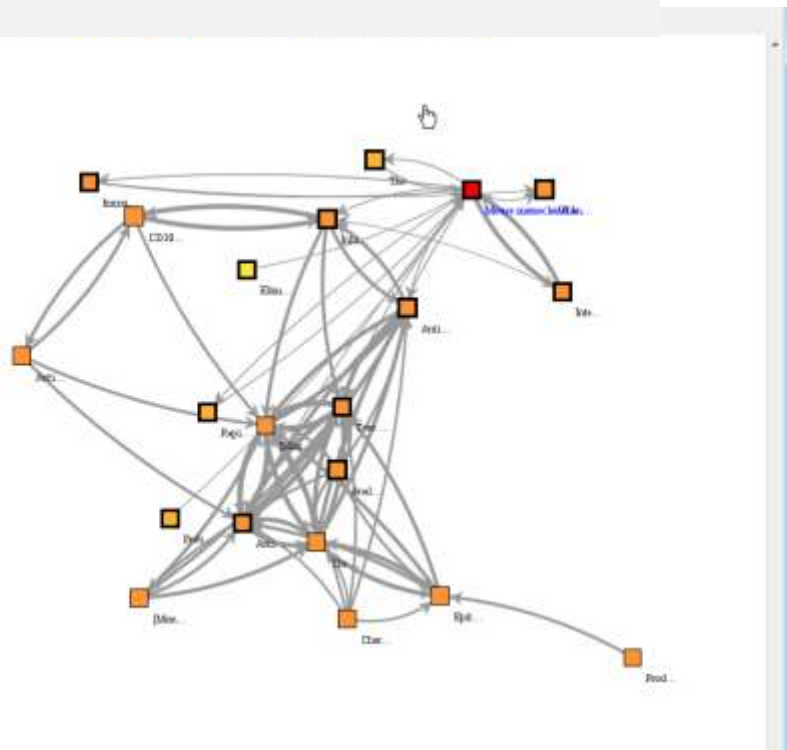
Visual history & annotation



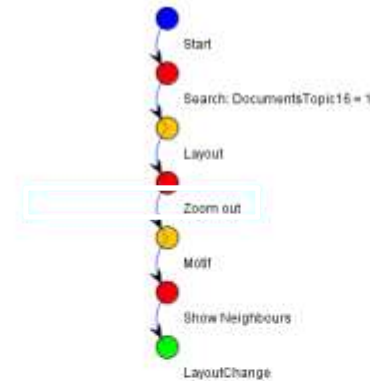
[von Landesberger et al 14]

Reasoning/Provenance

Visualization



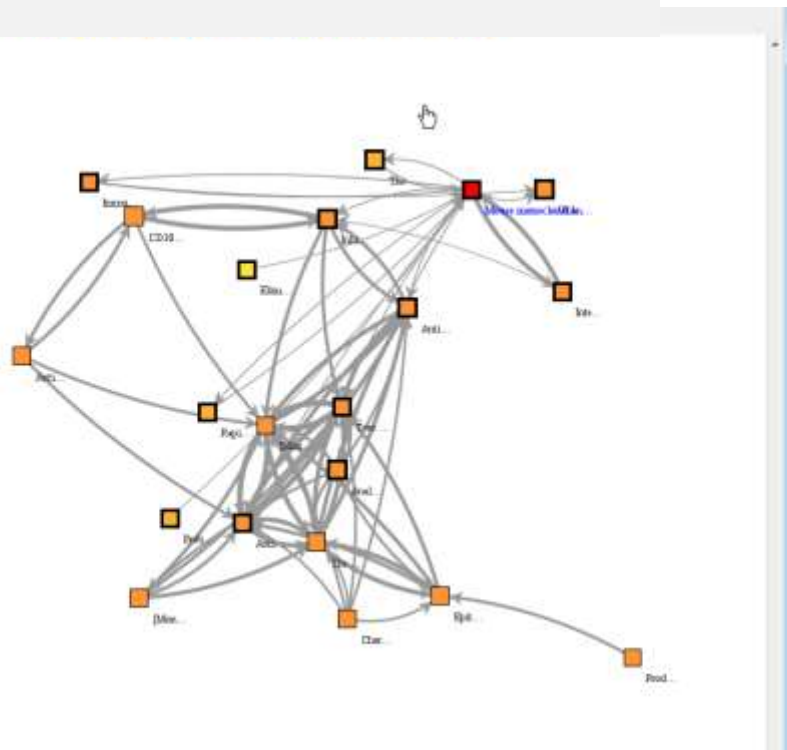
Visual history & annotation



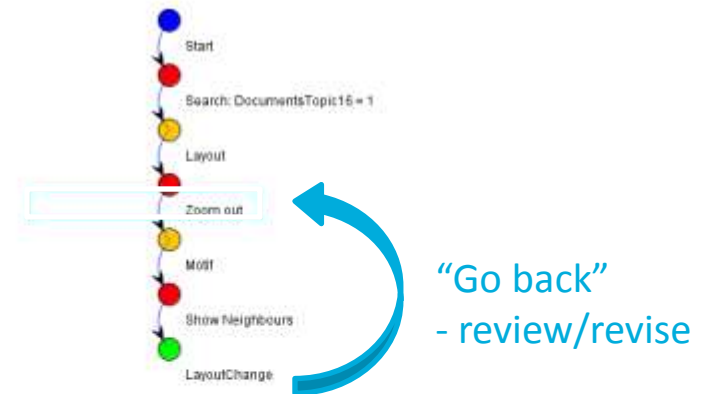
[von Landesberger et al 14]

Reasoning/Provenance

Visualization



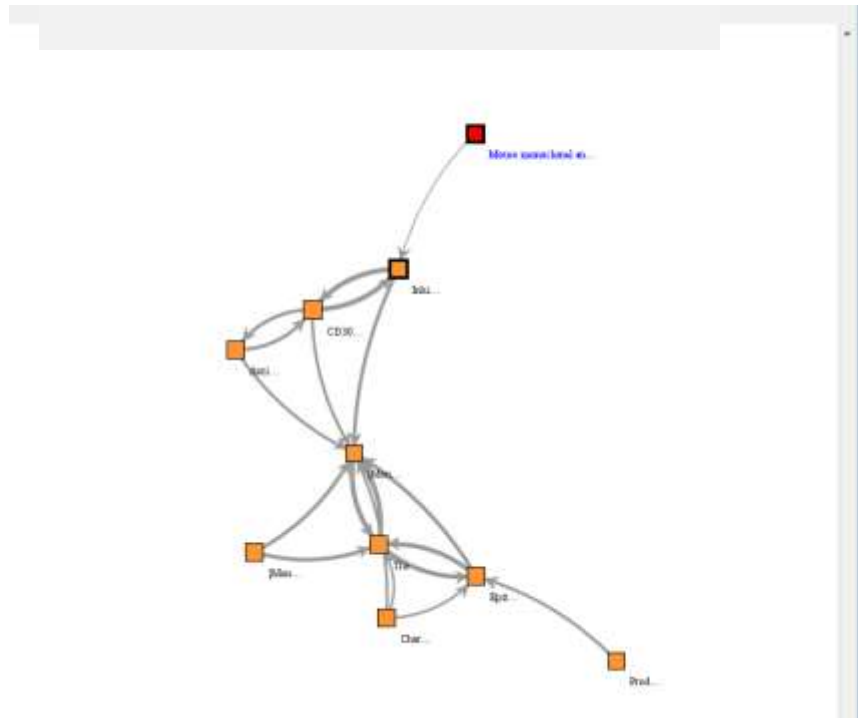
Visual history & annotation



[von Landesberger et al 14]

Reasoning/Provenance

Visualization



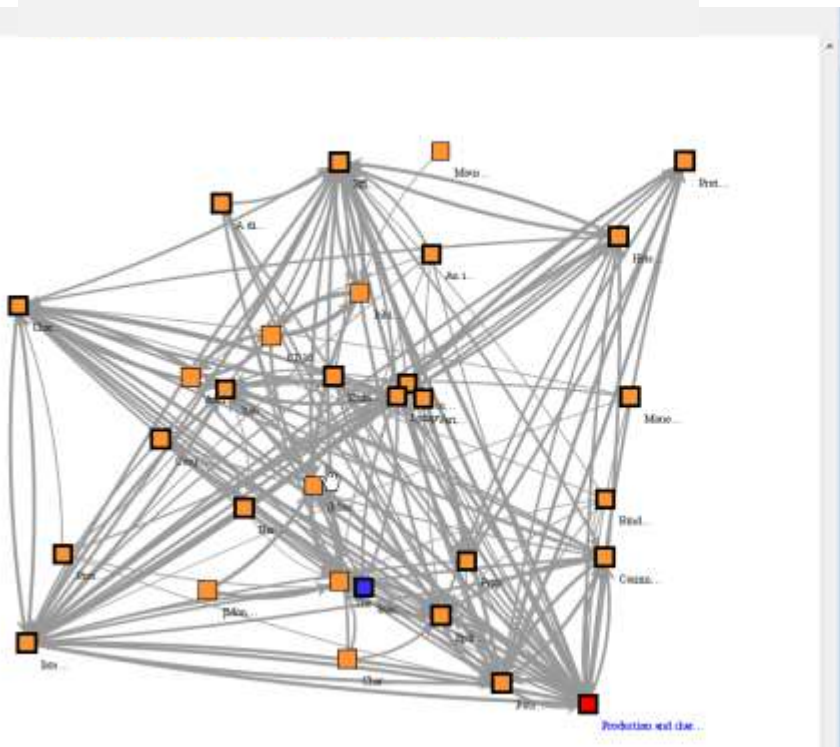
Visual history & annotation



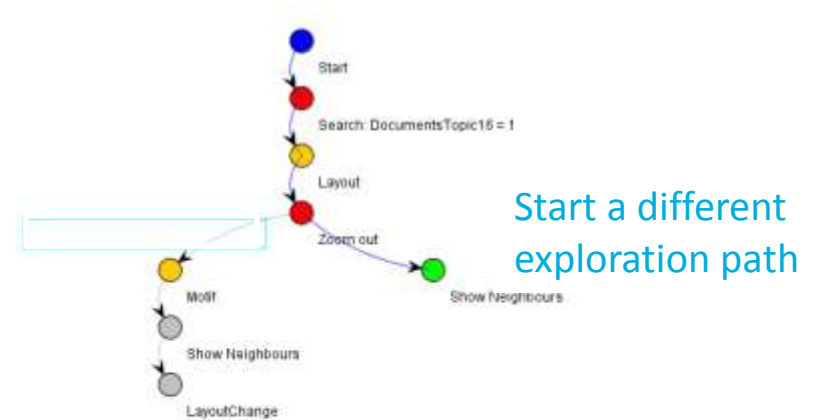
[von Landesberger et al 14]

Reasoning/Provenance

Visualization



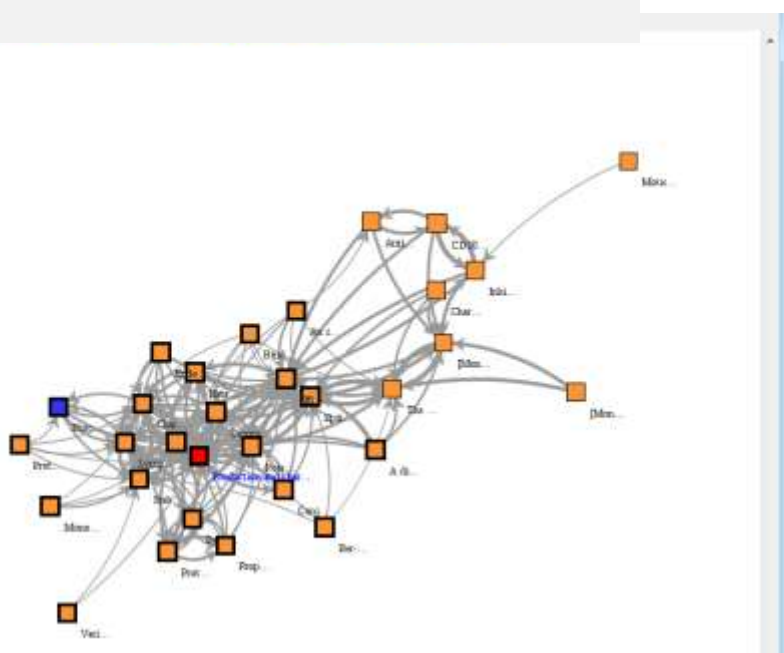
Visual history & annotation



[von Landesberger et al 14]

Reasoning/Provenance

Visualization

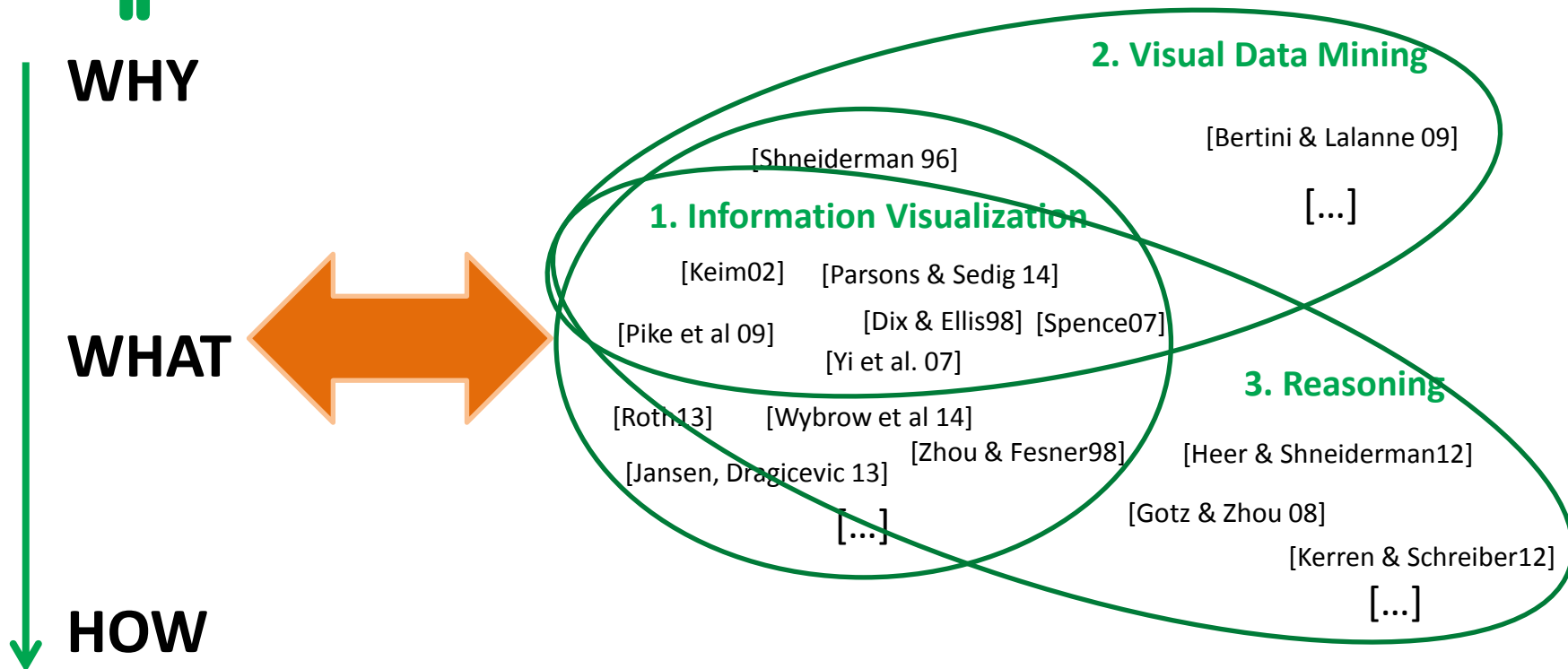


Visual history & annotation



[von Landesberger et al 14]

Systematization of Interaction



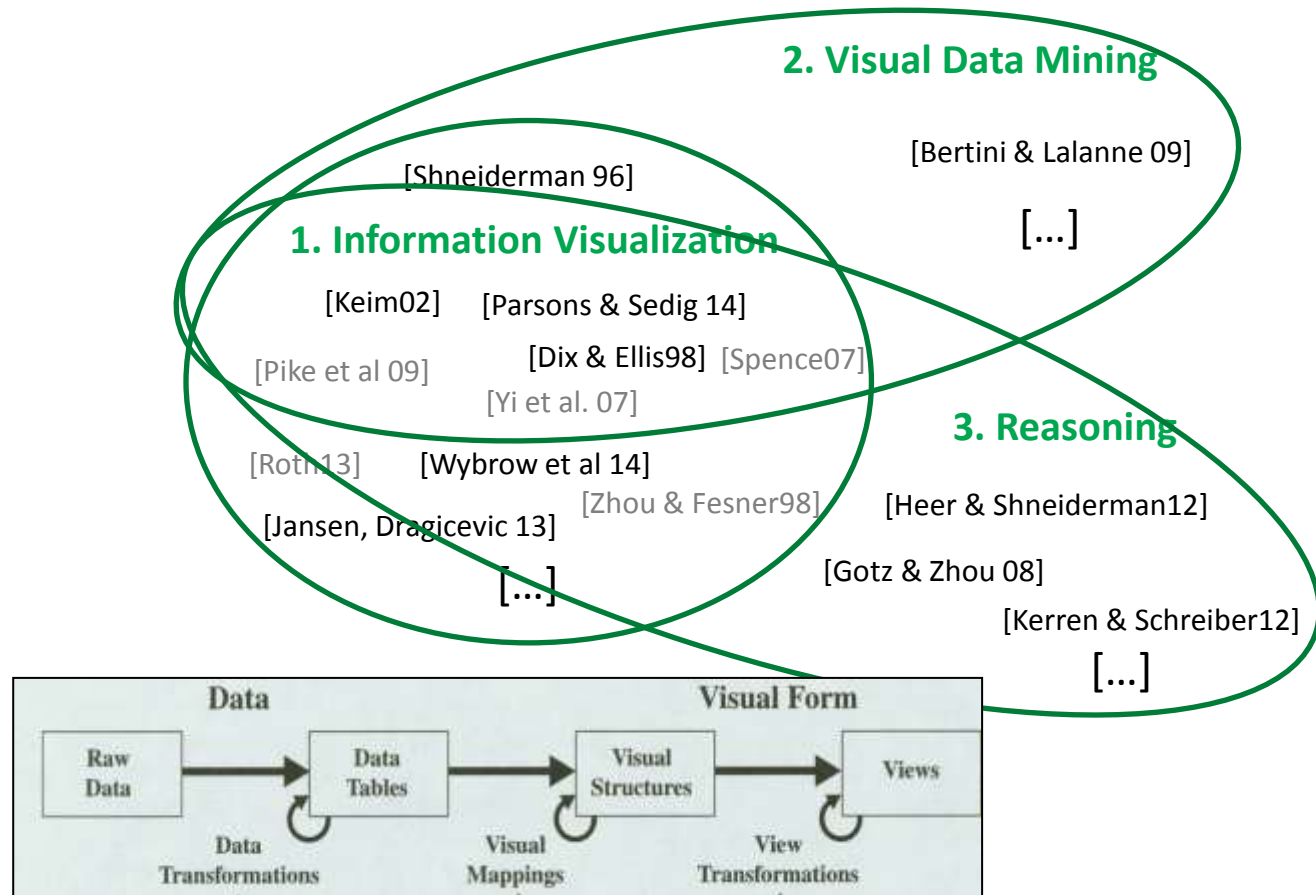
Systematization of Interaction - according to InfoVis Pipeline



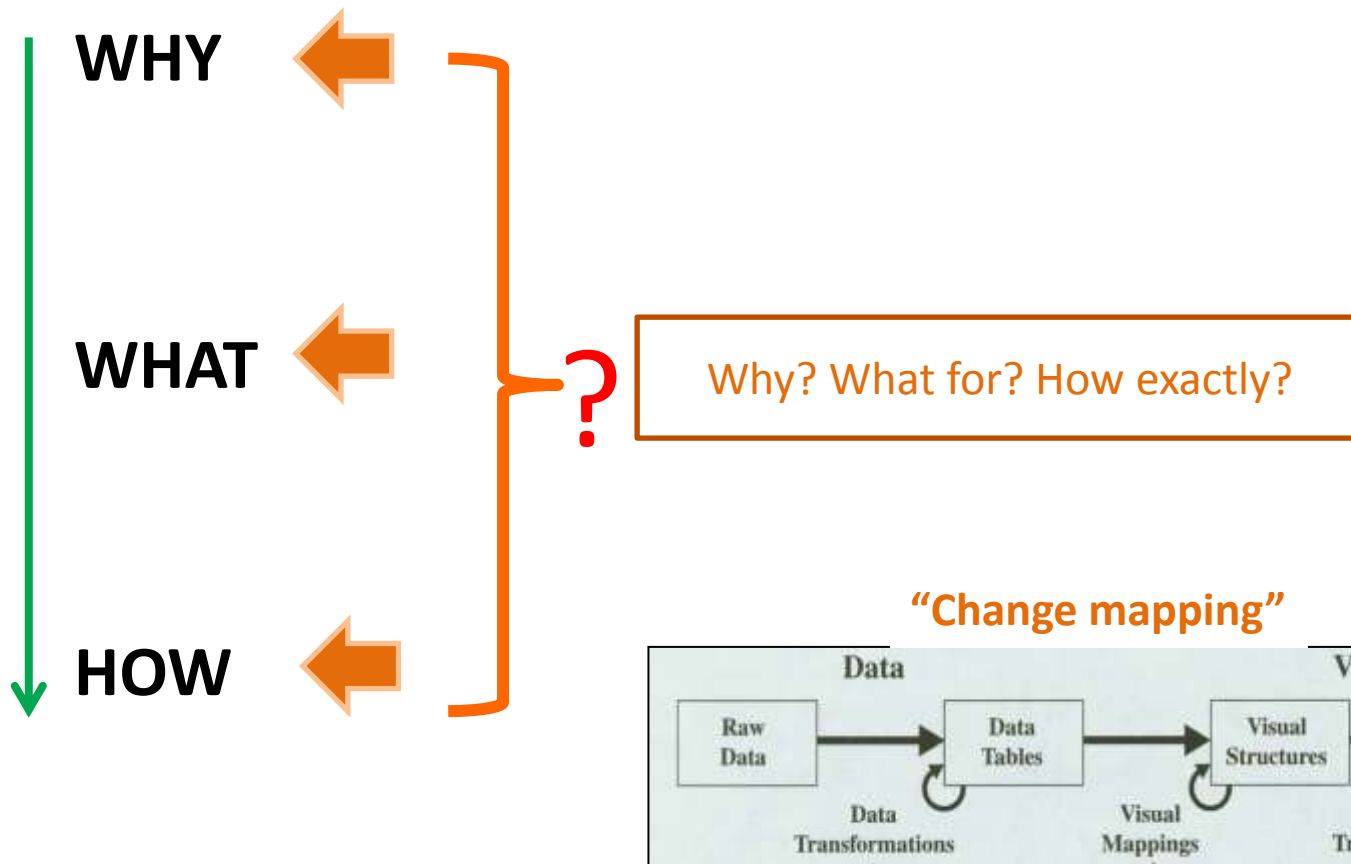
WHY

WHAT

HOW

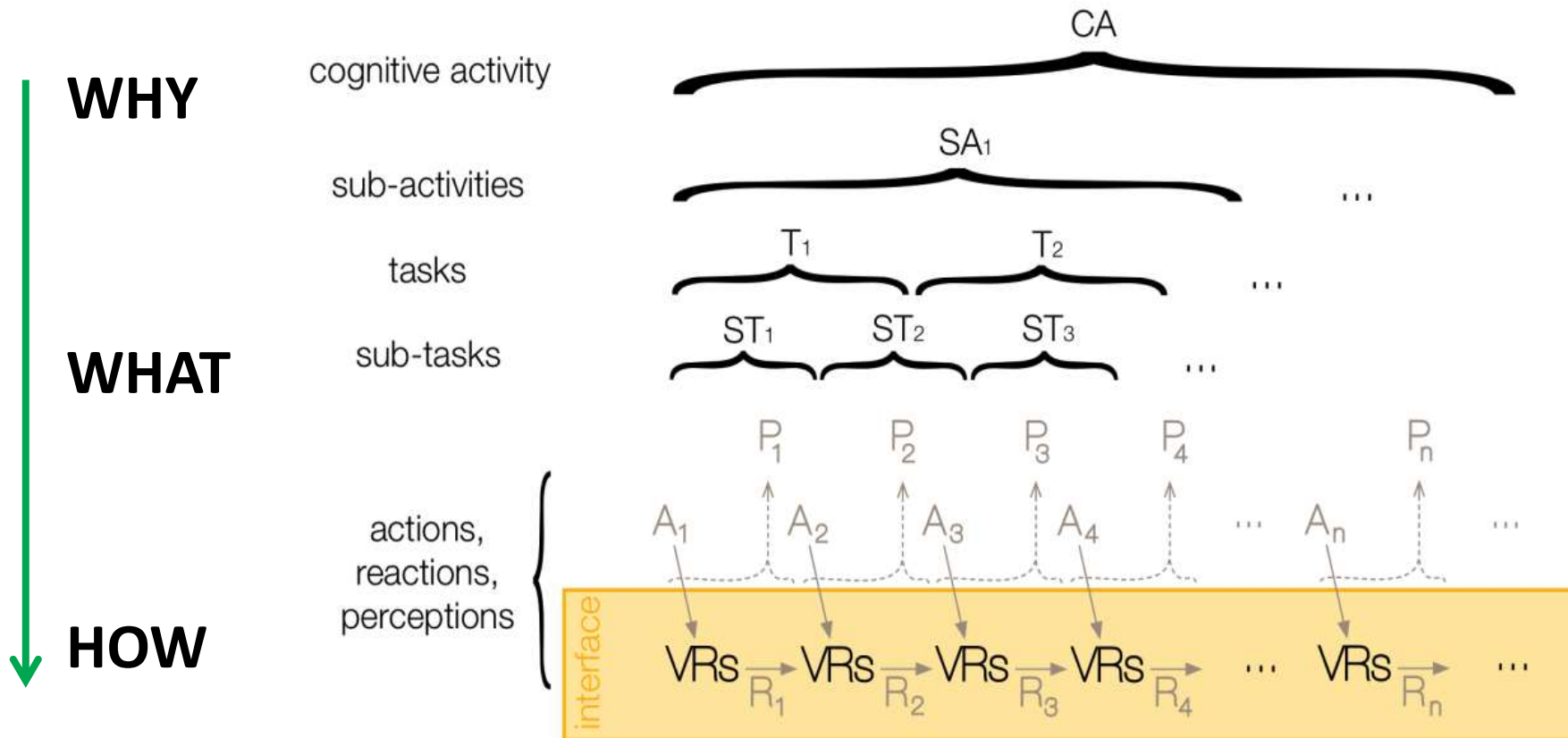


InfoVis-Focused Systematization: Problem of ambiguous terms



SYSTEMATIZATION: INTERACTION SUPPORT

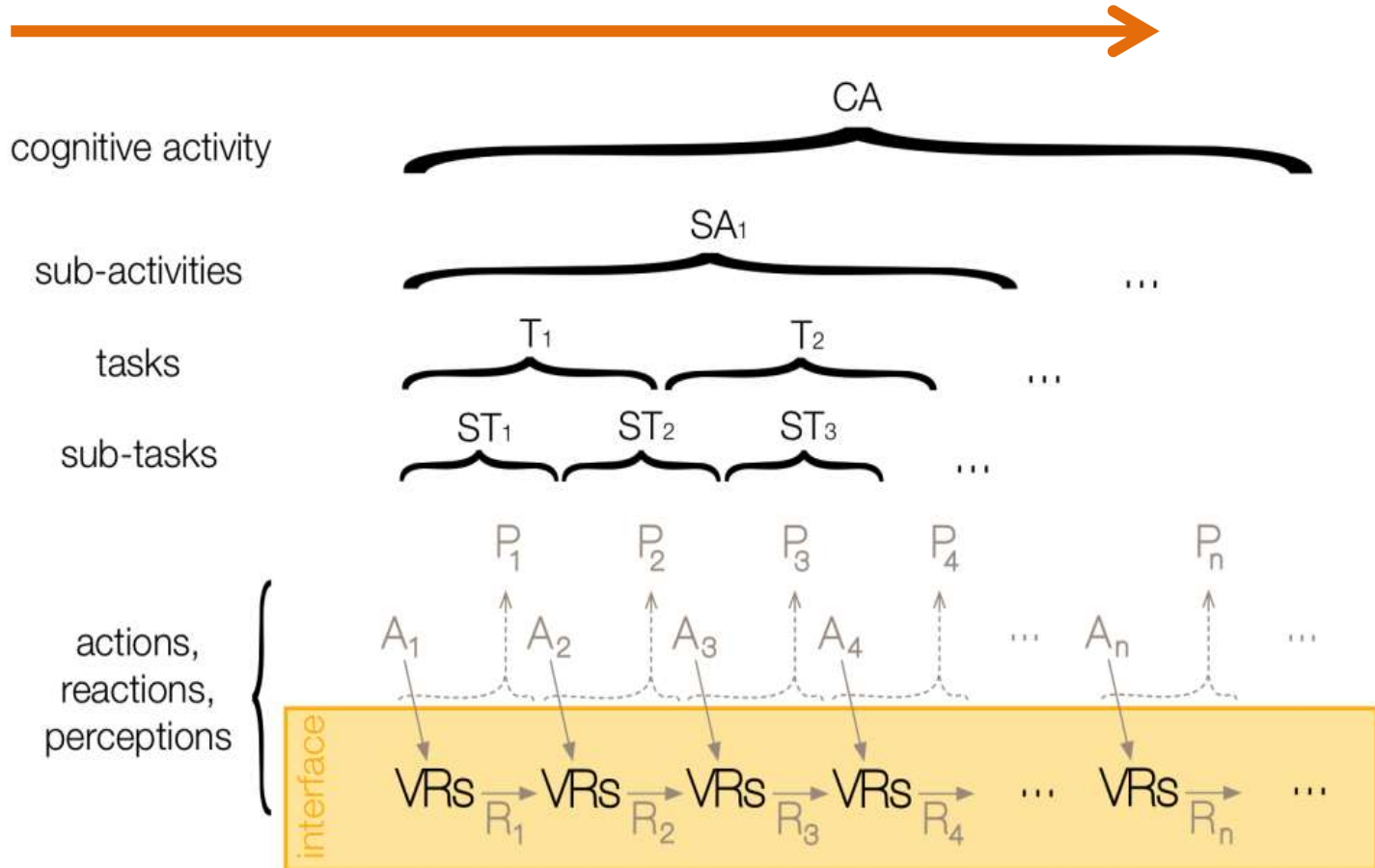
Interaction hierarchy



[Sedic & Parsons 10]

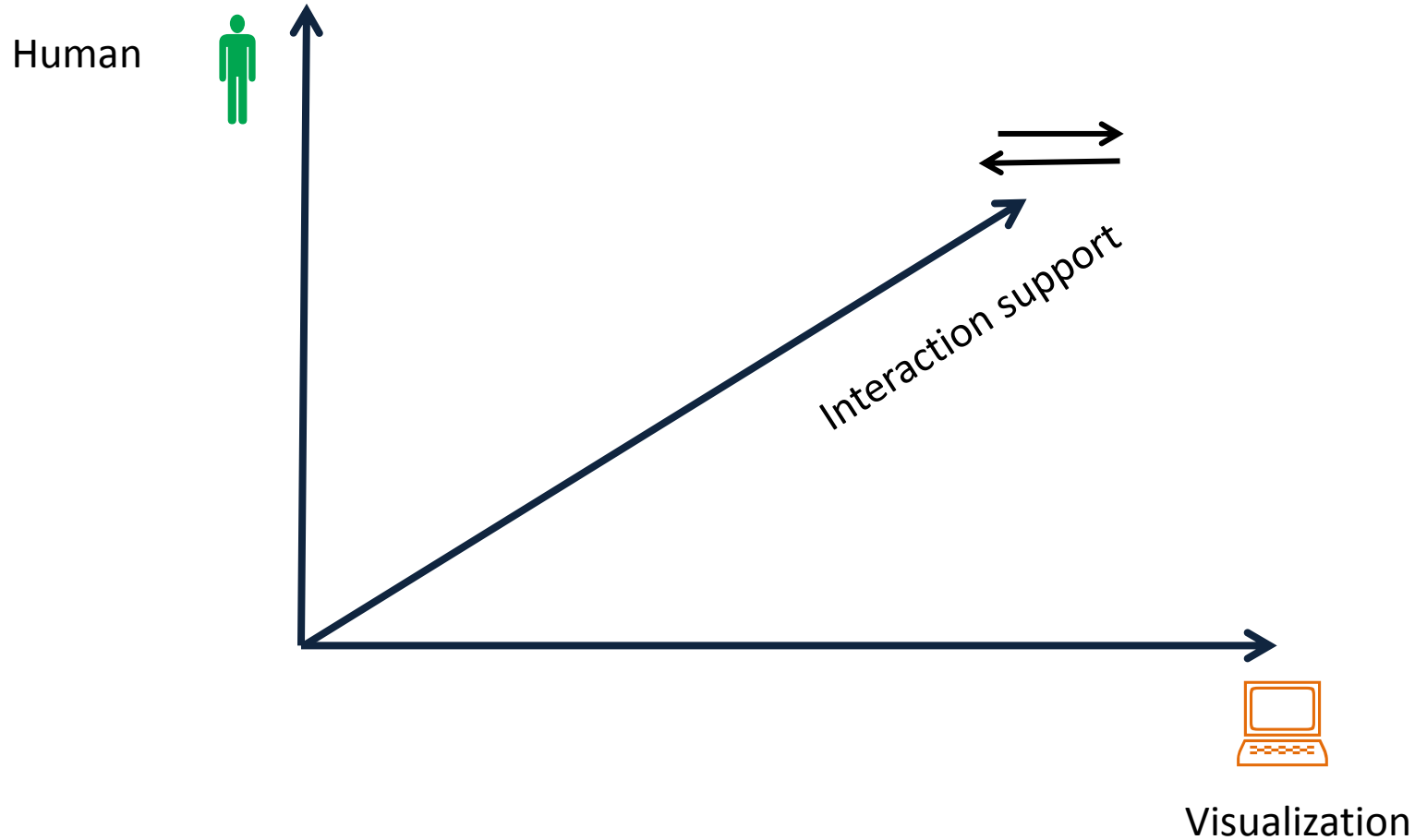
Interaction hierarchy

Time & cognitive burden

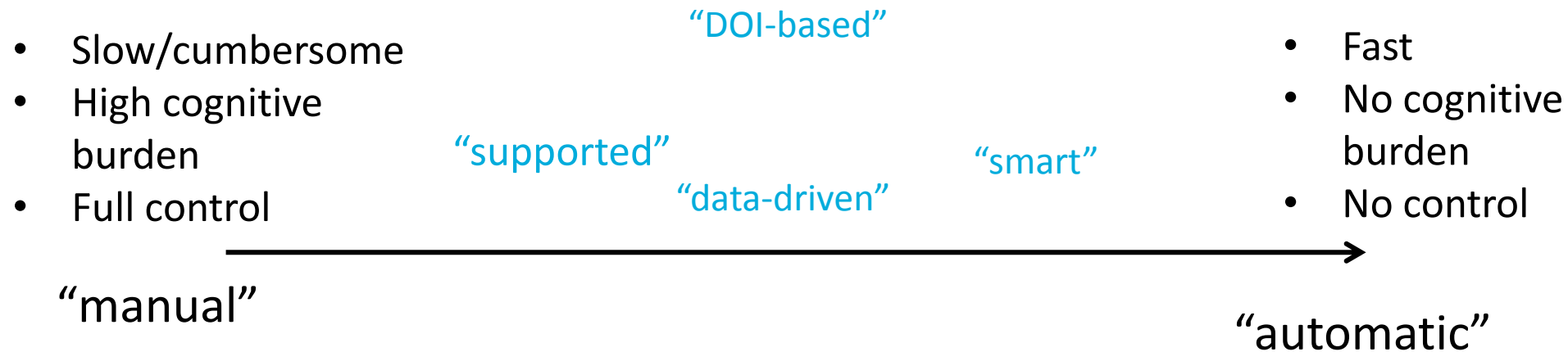


[Sedic & Parsons 10]

Three Dimensions:



Interaction support



Interaction support

- Slow/cumbersome
- High cognitive burden
- Full control

“supported”

“DOI-based”

“data-driven”

“smart”

- Fast
- No cognitive burden
- No control

“manual”

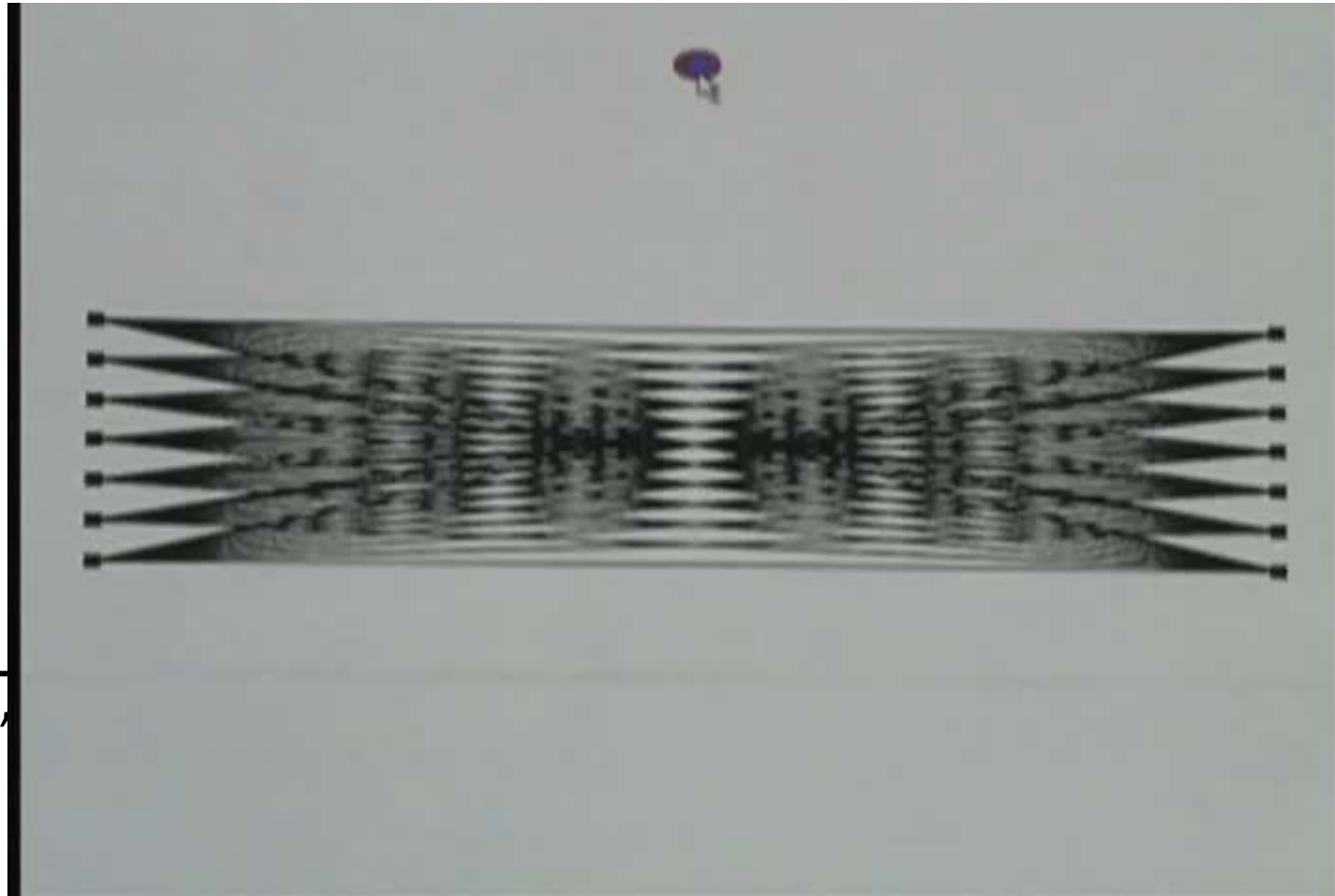
“automatic”



Interaction support

Supported

- Snap to grid
- **Edgelens**



“manual”

[Wong & Carpendale03]

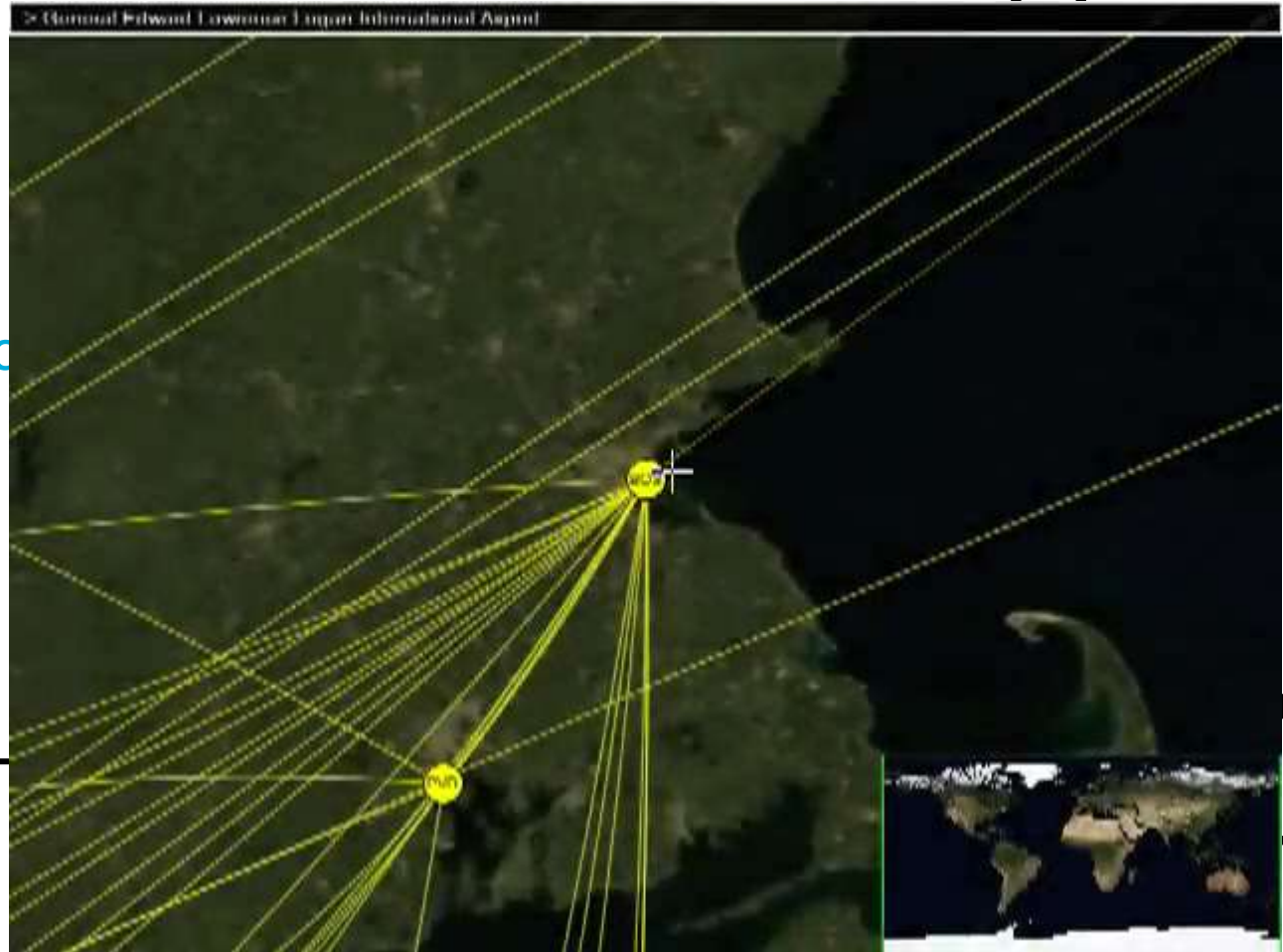
Interaction support

Data driven

- Topology-aware navigation
- Data-aware selection

- Slow/cumbersome
- High cognitive burden
- Full control

“manual”

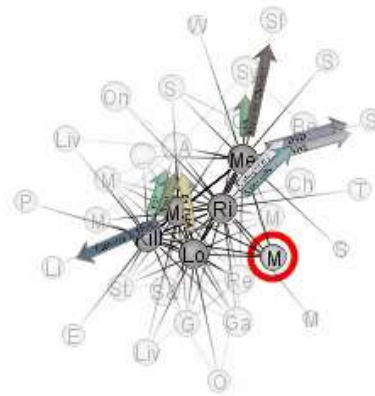


itive
rol

Interaction support

Guidance

- Small multiples
- DOI-based exploration



t''

- Fast
- No cognitive burden
- No control



“automatic”

Interaction support



[Heer et al 08]

Smart

- Tableau
“show me”

“smart”

- Fast
- No cognitive burden
- No control

“manual”

“automatic”



- Slow/cumbersome
- High cognitive burden
- Full control

Interaction support

Automatic

- [NodeTrix](#)

- Fast
- No cognitive burden
- No control



“automatic”

**Editing NodeTrix
using drag and drop interactions**

Part 1: Interaction actions

SUMMARY

Summary



WHY

WHAT

HOW



1. Information Visualization

[Shneiderman 96]
[Keim02] [Parsons & Sedig 14]
[Pike et al 09] [Dix & Ellis98] [Spence07]
[Yi et al. 07]
[Roth13] [Wybrow et al 14]
[Jansen, Dragicevic 13] [Zhou & Fesner98]
[...]

2. Visual Data Mining

[Bertini & Lalanne 09]
[...]

3. Reasoning

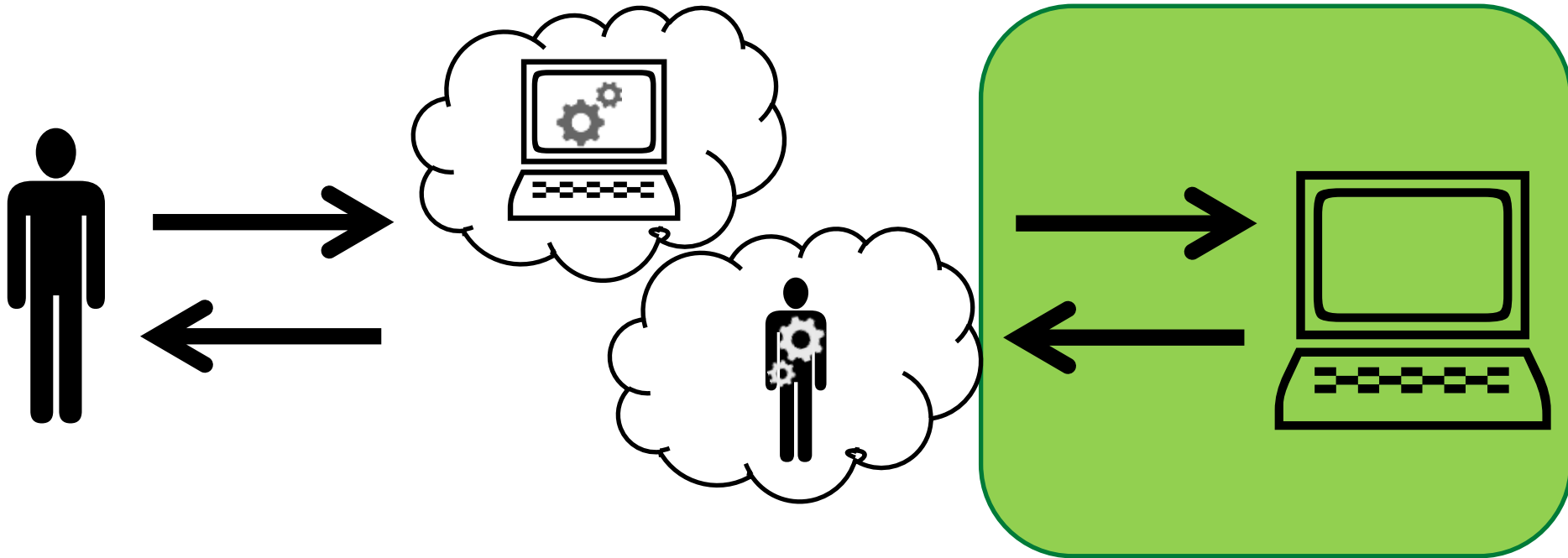
[Heer & Shneiderman12]
[Gotz & Zhou 08]
[Kerren & Schreiber12]
[...]

THANK YOU

Q&A

Next: Interaction architecture

Hans-Jörg Schulz



Activities: What the user does to trigger a change in the computer (*Action*)

Metaphor: What the user thinks the computer is doing and vice versa (*Understanding*)

Architecture: What the computer actually does (*Reaction*)