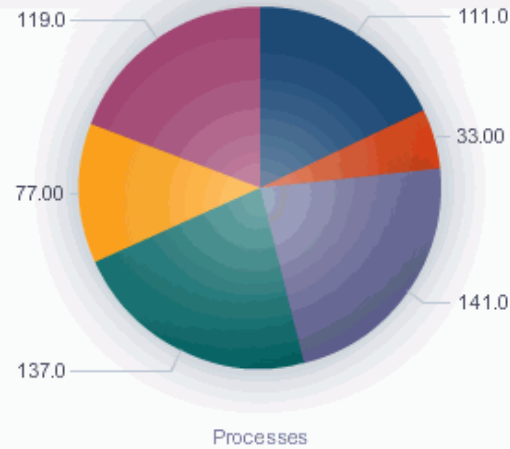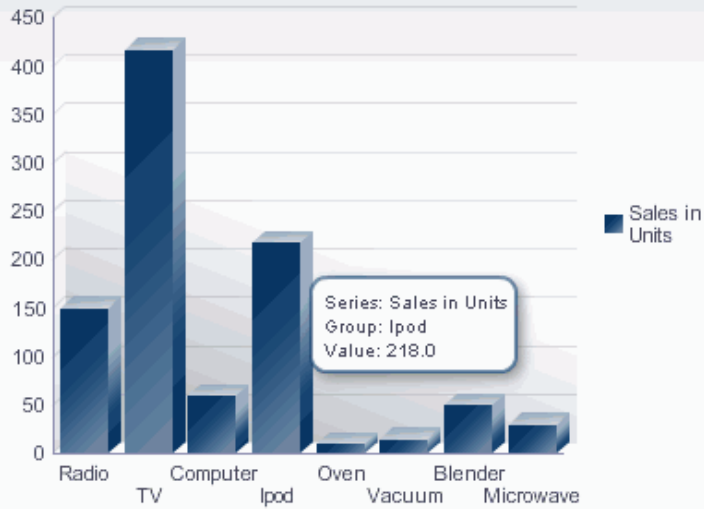# Semiotics in Digital Visualisation

**keynote at International Conference on Enterprise Information Systems
Lisbon, Portugal, 26 – 30 April 2014**

Professor Kecheng Liu
Head, School of Business Informatics, Systems and Accounting
Director, Informatics Research Centre
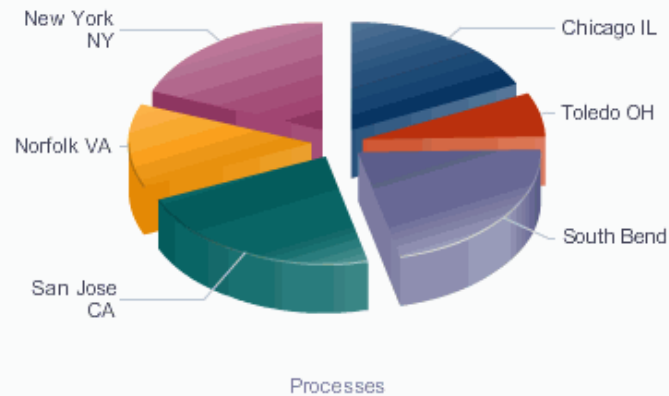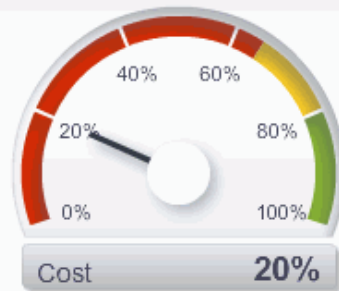Henley Business School

Content

- Digital Visualisation
    - Components and Process
    - Challenges and Reflection

- A Semiotic Perspective to Digital Visualisation
    - Semiotics (Semiosis and Abduction)
    - Data visualisation is a process of abduction

- Principles of Digital Visualisation

A picture is worth for a thousand words

Digital Visualisation

- In general, digital visualisation is
  - Presenting information from data by
    - using graphical techniques
    - gaining insights and understanding
    - engaging human being

      (Czernicki, 2010 , Spence, 2007, Ware, 2012)

  - Ranging in complexity
    - simple forms, e.g. charts and graphs (i.e., visual representation of data of only two dimensions)
    - complex forms, e.g. animated visualizations, with possibility for user's interact with the underlying data visually (e.g., Tableau)

      (Unwin, Chen, and Härdle , 2008)

Digital Visualisation Components

Information

Knowledge

Digital visualisation

Data

contribute
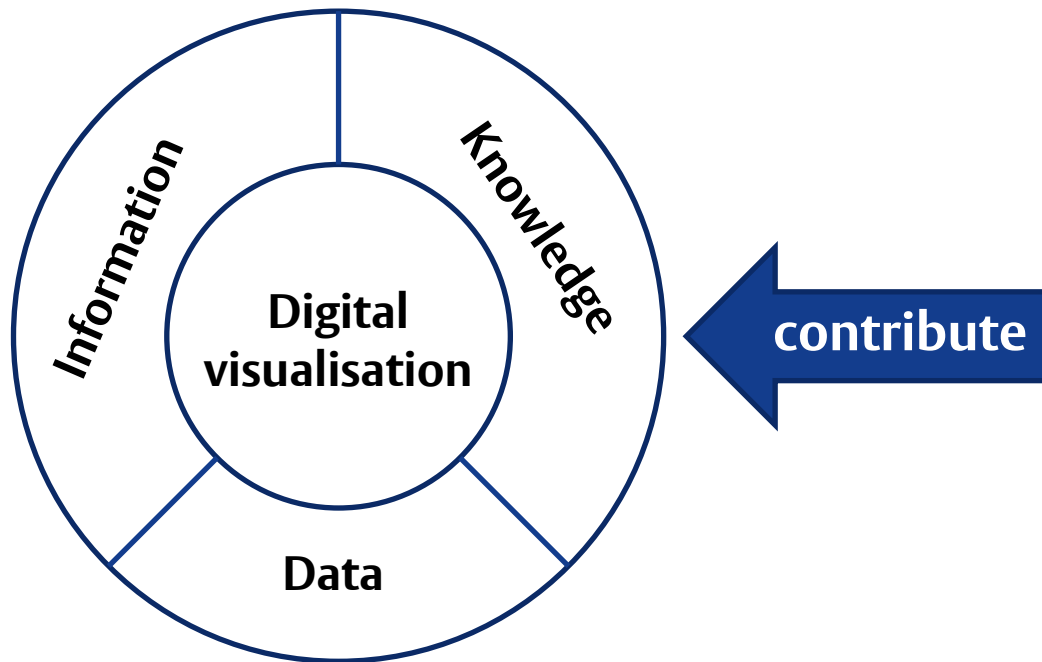
Social – Human perception

Technical – Enabling visualisation
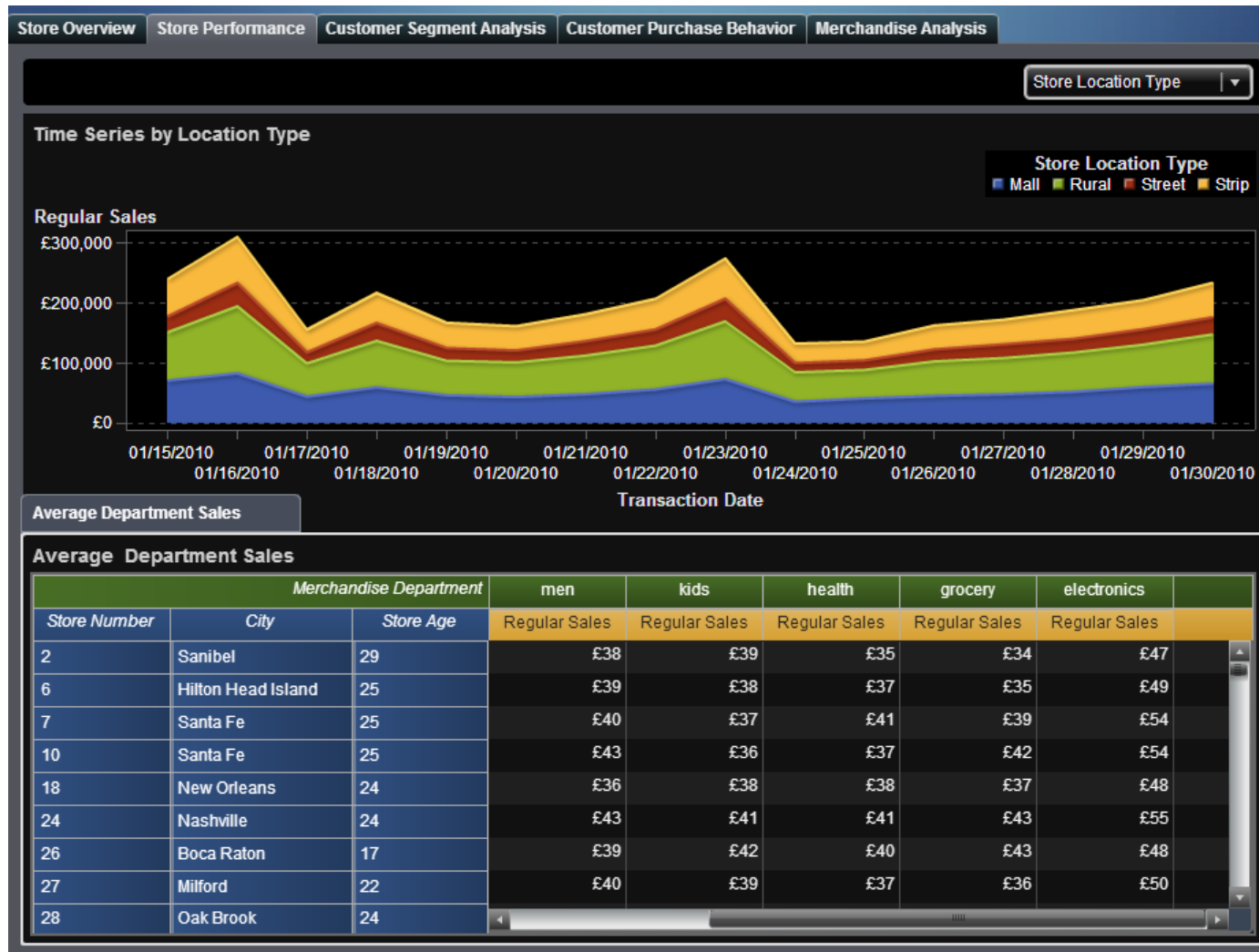
Digital Visualisation Components (cont.)

Component	Social (Human Perception)	Technical (Enabling Visualisation)
Data	Figures, numbers, text	Representing abstracted data schematic form, including attributes or variables for the units of data (direct display, no deep processing)
Information	Processed data that answers *what*, *who*, *where*, *when*, *why* and *how* questions	Showing / emphasising on relationship between data items; with interpretation; show semantics
Knowledge	Application of data that explains the *type* or *patterns* of a situation or context	Representing the effect on organisation through visual analytics on social, on economy, e.g. drop on sales, decision-making by looking at alternatives

Digital Visualisation – An example

Source: http://www.sas.com/software/visual-analytics/demos/customer-analysis.html

The Process of Digital Visualisation

Intentions
Effects
Purposes

| Data gathering | Data exploration | Viewing manipulation | **Interpret meaning / interaction** |

| Data collection | Data Transformation & Filtering | Visual mapping | Display & Interaction |

Data collection
- Requirements & query
- Structured data & unstructured data

Data Transformation & Filtering
- ETL (Extract, Transform, Load)
- Data mining techniques (e.g. clustering, remove noise, filtering, and classifications)

Visual mapping
- Graphic engine (visual objects)
- Geometric primitives (e.g. points and lines)
- Attributes (e.g. color, position and size)
- Rendering (transform data to image)

Display & Interaction
- UI control
- Explore data from multiple perspectives
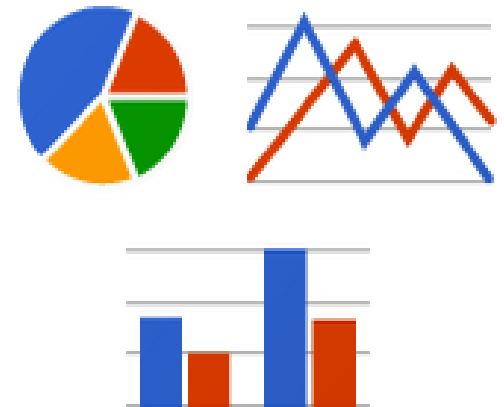
Digital Visualisation Challenges

- Semantic issue - The fallacy of 'seeing is believing'
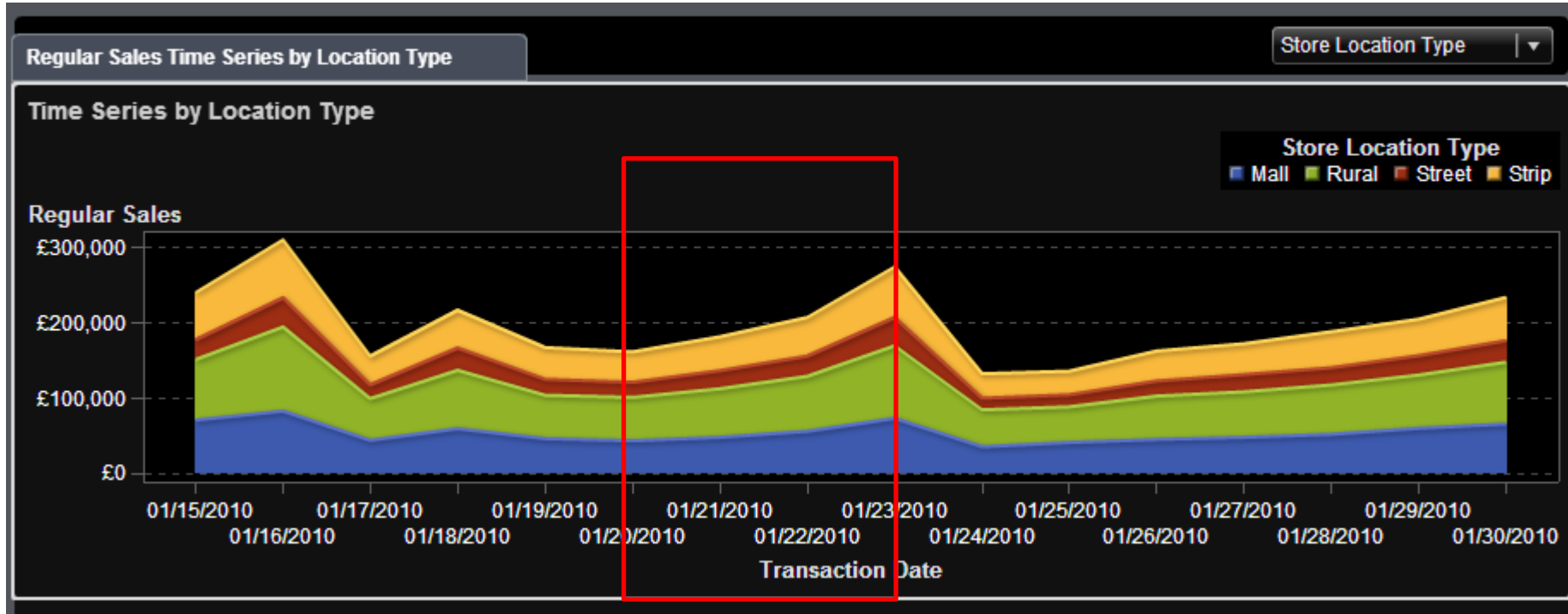
It looks like there is a sales hike from 20 to 23 Jan. In fact, it is only a slow increase in sales indeed.

(Evergreen et al., 2013)

Digital Visualisation Challenges (cont.)

- Pragmatic issue –
  - The intention / purpose of digital visualisation is not reflected
  - There is always a <u>purpose</u> how digital visualisation is designed
  - <u>Many data sources</u> are required to achieve the purpose, hence it is challenging to:
    - ensure the <u>data reliability</u>
    - select the <u>right information</u> to visualise
    - select <u>right graphic</u> to visualise information

(adapted from Evergreen et al., 2013, Tufte, 2006)

Reflection

Digital visualisation is an analytical reasoning

Information

Knowledge

Digital visualisation

Data

Helps in
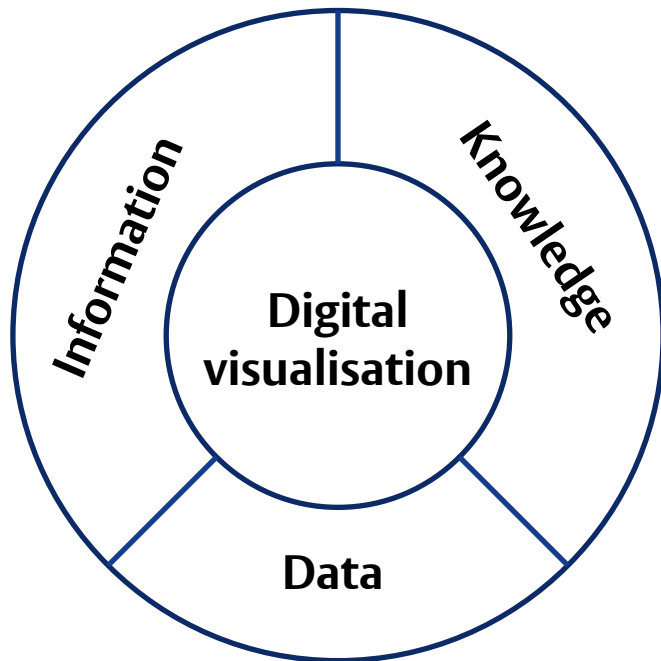
Show the data syntax

Convey the meaning of data

Focus on the intention of using data

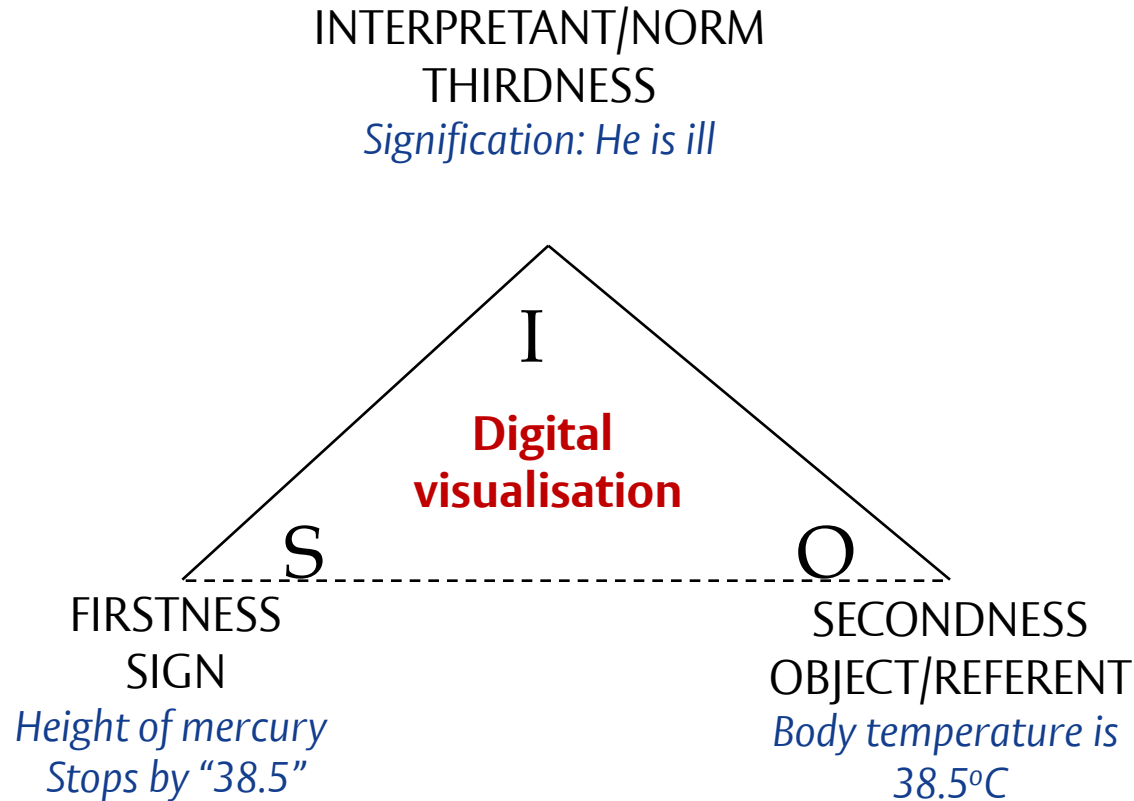# Semiotic Perspective to Digital Visualisation
- *Semiotics*

- ## Semiotics
  - Formal doctrine of signs (Peirce, 1935)
  - the discipline of signs whereby the signs and their properties and functions are studied

- ## A Sign
  - is something which stands to somebody for something else in some respect or capacity
  - e.g.:
    - Is pen a **writing tool** or a **sign**?

Semiotic Perspective to Digital Visualisation
- *Semiosis*

INTERPRETANT/NORM
THIRDNESS
Signification: He is ill

I

**Digital
visualisation**

S   O

FIRSTNESS
SIGN
*Height of mercury
Stops by "38.5"*

SECONDNESS
OBJECT/REFERENT
*Body temperature is
38.5ºC*

(Liu, 2001)

Semiotic Perspective to Digital Visualisation
- *Norms*

- Norms
  - Patterns, regulations, rules, laws
  - Descriptive and prescriptive
    - Formed in society or cultural groups
    - To govern the pattern of behaviour

Semiotic Perspective to Digital Visualisation
- *Types of Norms*

- **Perceptual**
  - how people receive signals about the environment.
  - e.g. the distance between two bollards is wide enough to drive the car through

- **Cognitive**
  - how people interpret the signals they have received
  - e.g. an illuminated red light above an orange and green means stop

- **Evaluative**
  - explain why people have beliefs, values and objectives
  - e.g. frankness in debating between employee and boss; openness in voicing personal views

Semiotic Perspective to Digital Visualisation
- *Types of Norms*

- **Denotative**
  - culture dependent, direct the choices of signs for signifying
  - e.g. stop signals are red and octagonal

- **Behavioural**
  - govern people's behaviour within regular patterns
  - e.g. if a library book is overdue than the borrower must pay a fine

Semiotic Perspective to Digital Visualisation
- *Abduction*

- In Peircean logical system,

  "**Abduction** is the process of forming an explanatory hypothesis. It is the only logical operation which introduces any new idea"   (Peirce, 1878)

- Abduction is used
  - to generate hypotheses
  - to determine which hypothesis or proposition to test (Yu, 1994)
  - followed by
    - deduction to explicate and to apply to problems
    - Induction for empirical experiments and generalisation of theory/knowledge
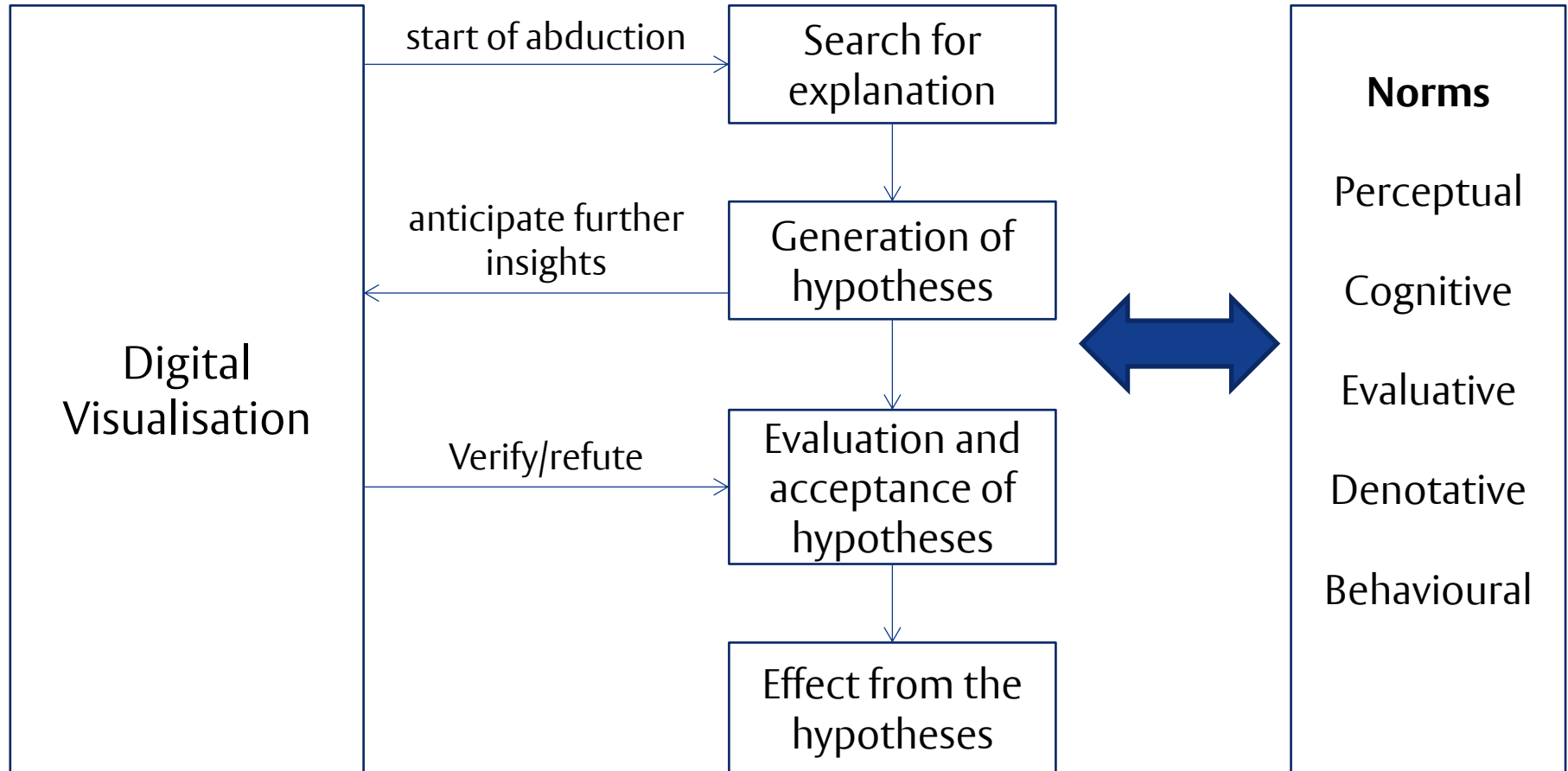
Semiotic Perspective to Digital Visualisation
- *Abduction (cont.)*

Examples of abduction in five domains (Thagard, 2007)

Domains	What to be explained?	Hypotheses that explain
Science	Experimental results	Theories about structures and processes
Medicine	Symptoms	Diseases
Crime	Evidence	Culprits, motives
Machines	Operation, breakdowns	Parts, interactions, flaws
Social	Behaviour	Mental states, traits

Semiotic Perspective to Digital Visualisation
- *Digital visualisation is a process of abduction*

Digital Visualisation

start of abduction → Search for explanation

anticipate further insights ← Generation of hypotheses

Verify/refute → Evaluation and acceptance of hypotheses

Effect from the hypotheses

Norms

Perceptual

Cognitive

Evaluative

Denotative

Behavioural

Discussion and Conclusion

- The principles of digital visualisation
  - Context-aware and purpose-driven
    - Representation / display constitutes context or purpose
    - Consider the effect of information on end users, rather than on the intended meaning supplied by the providers

  - Subject-dependent with high interactivity
    - Representation / display leads to hypotheses with the abduction process
    - Key function of interaction, continued clarification by verification and refutation

  - Norm-centric
    - Driven by norms in graphical visualisation
    - To discover knowledge (i.e. norms) as ultimate goal

Discussion and Conclusion (cont.)

- Digital visualisation is a process of abduction

  - Assist human to interact with data

  - Enhance understanding of the meaning of data (information)

  - Discover pattern from data (knowledge)

  Through generation, verification and refutation of hypothesis

- Contribution of semiotics in digital visualisation

  - Capture human intention / purpose / knowledge

  - Encourage user involvement and interaction with visual analytics