# Individual differences on e-learning

Universiteit Utrecht

## 3. INDIVIDUAL DIFFERENCES IN E-LEARNING

- Cognitive issues in using hypertext (Rouet, 2006)
  - Hypertext reading and Comprehension
    - Cognitive load
    - Relational processing
  - Searching for information in Hypertext
  - Prerequisite cognitive skills in hypertext learning
    - Navigation
    - Integration
    - Sourcing
    - Corroboration
- Individual differences (Anderson, 2001)
  - Personality
  - Cognition
  - Prior knowledge
- Adaptive hypermedia systems
  - Adaptive presentation
  - Adaptive navigation support
  - AES-CS



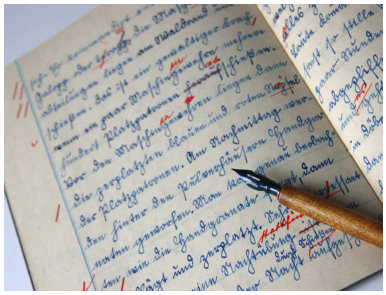
## Contents

- Cognitive issues in using hypertext
  - Hypertext reading and Comprehension
    - Cognitive load
    - Relational processing

## Reading of linear versus nonlinear text

- **Hypothesis**
  - For tasks that require the use of vast amounts of information, readers may benefit from advanced linking and navigation facilities (Rouet, 2006)

- Martin & Platt (2001): reading online is slower
- O'Hara & Sellen (1997): the physical and visual differences have consequences on students reading strategies
  - 10 researchers to summarize a 4 page scientific report
  - Online versus paper
  - Note taking was necessary but more cumbersome and effortful in the online condition
  - In the paper condition users lay out documents on the desktop to get a sense of the structure of the document



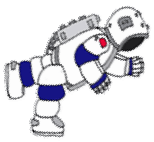


## Comprehension of linear versus nonlinear text

- Early studies: lost in hyperspace
  - Subjects reported difficulties in defining an optimal reading order
  - And locating themselves in the network (i.e. Edwards & Hardman, 1989)
  - Problems
    - Looping: go back several times to the same units
    - Jumping: do not follow relations between units

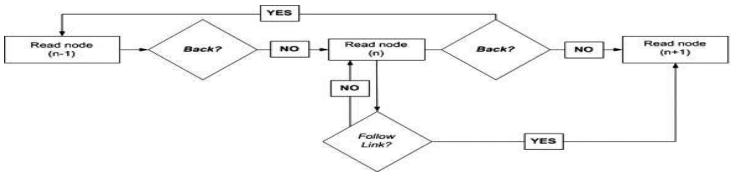
- More recent studies: lost again!
  - Lee & Tedder (2003): hypertext presentation of a history text compared to linear presentation
    - detrimental effects in comprehension

- **Hypothesis**:
  - Hypertext reading creates higher **cognitive load** and reduces the readers ability to memorize content information



# Higher cognitive load

- Reader has to make decisions about what links to follow (DeStefano & LeFevre, 2005)




- Keep track of pages previously visited (Wright, 1991)
- But also deeper **relational processing**?

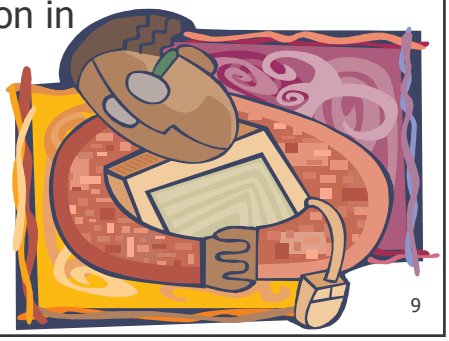


# Deeper relational processing?
(Wenger & Payne, 1996)

- Can be beneficial for text that normally do not normally foster this type of processing
  - Wenger & Payne (1996)
    - 40 university students read either
      - Six causal texts or Six descriptive texts
      - Linear or nonlinear
      - Comprehension
        - For causal text better with linear representation of information
        - For descriptive text better with nonlinear representation of information
- Reading hypertext may stimulate the use of cognitive resources that are not used spontaneously when reading linear text
  - So greater effort
  - But also deeper processing of the material

# Contents

- Hypermedia learning systems
- Cognitive issues in using hypertext
  - Hypertext reading and hypertext Comprehension
  - Searching for information in Hypertext





# Searching for information in Hypertext

- Hypertext was primarily designed to facilitate
  - information search
  - Readers' interactions with large textual databases
  - For tasks that require the use of vast amounts of information
    - Advanced linking and navigation facilities
    - Cross-referencing
- Mixed results
  - Spatial abilities
  - Novices vs. experts in the domain of knowledge (we will see later!!!)

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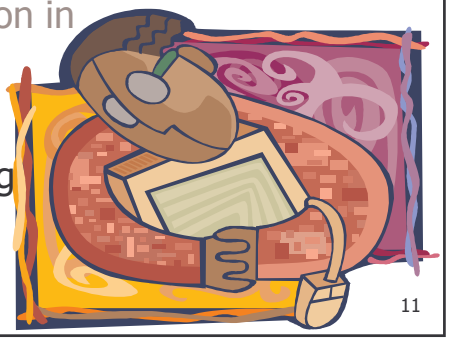
  - Prerequisite Cognitive skills in hypertext learning





## Prerequisite Cognitive skills in hypertext learning

- Navigation skills
- Integration, sourcing and corroboration
- Coordinating both activities

# Navigation skills

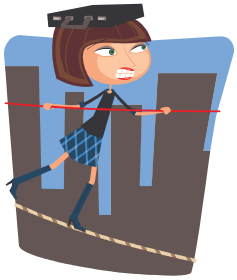
- Planning and executing a route through the network
  - Visuospatial ability
    - Mentally construct and manipulate spatial representations
  - Construction a mental representation of the locations and depth of pages
    - E.g. Downing et al (2005)
      - time needed to access information shorter in participants with high spatial skills
      - Independent of their expertise in the topic
- Really the same navigational skills than in physical spaces?
  - Semantic dimensions also need to be taken into account
  - Experts have the advantage of semantic knowledge



## Cognitive skills for hypermedia learning and using internet for research (Britt & Gabrys, 2001)

Hypermedia creates new learning demands

- Sourcing
- Integration
- Corroboration



These are all characteristics of experts readers!!!

# Sourcing

- Noticing and evaluating the source of the read document for the purpose of **assessing the credibility** of the information contained in the document
- Sourcing involves
  - Identification of relevant information
    - Scholar.google.com (beta)
    - www.Sciencedirect.com
  - Evaluation
    - Constructing a model of the author (e.g. name, credentials, motives, date of writing…)
    - Evaluating the content with the model
  - Use and keep track of the source to find it afterwards

Need to improve these abilities!



# Integration of nonlinear reading

- Making connections across pages
- Making connections between prior and new knowledge
  - Mental effort to make associations
- Increases the number of documents that require integration
  - Use of short documents
- Dealing with inconsistencies among sources
- Readers are expected to guide their own learning process

Hypertext is better suited to users with some amount of domain knowledge than to novices

## Corroboration by other sources

- Checking facts or interpretations from a document against other independent sources
  - Searching documents for comparison
    - Sources mentioned in the document
    - Collected bibliographies on the topic
    - Databases (e.g. PsychInfo)
    - Search engines (boolean query)
  - Comparison process of documents
    - To identify agreements, discrepancies,…

Need to improve these abilities!



## Contents

- Cognitive issues in using hypertext
- Individual differences (Anderson, 2001)

# Individual differences

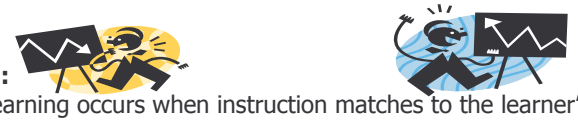
ATI: aptitude-treatment interaction (Snow, 1989)

Research on how performance is influenced by individual characteristics and the learning environment

Different individuals

Different Learning environments

Different performances



**Assumption:**

Optimal learning occurs when instruction matches to the learner's aptitudes



# Characteristics of the learner

- Personality
  - Ambiguity tolerance
  - Anxiety
  - Locus of control
- Cognition
  - Learning Style
  - Executive cognitive processes
  - Prior knowledge

# Contents

- Hypermedia learning systems
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- Individual differences
  - Personality factors
  - Cognitive aspects



**Cognitive aspects**

**Learning Style**

**Prior knowledge**

# Learning style

- Individual's learning preferences, learning skills, strategies and study orientation (Schmeck, 1988)

- Field dependence / independence
- Passive / active learner
- Depth of cognitive processing
- Verbalizers vs. visualizers



# Field independence

People's ability to reason independently from salient features in the perceptual environment

**FIELD INDEPENDENT**

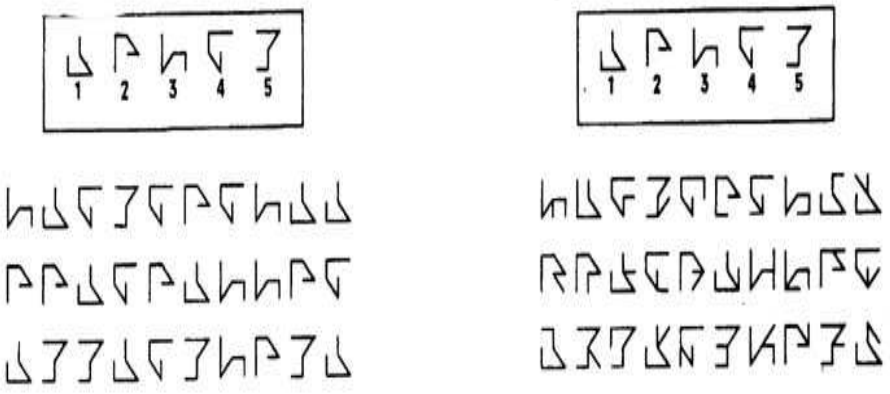
- Analytic
- Logical and organized
- Perform better with discovery instructional methods (e.g. distant education)
- Intrinsic motivation (self-study)
- Self-referent
- Clear ideas on their own values

**FIELD DEPENDENT**

- Rely on external cues and less able to rely on their own judgments
- Holistic
- Difficulties organizing their own learning activities
- Perform better with guidance
- Socially sensitive and influenced by social and physical background

- Kim (2001): field-independent students develop more efficient navigation strategies

*"read the codes of the figures in the matrix as fast as possible"*





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  - Cognitive aspects
  - Prior knowledge

## Prior knowledge: novices vs. experts

- In hypermedia (Chen et al, 2004):
  - Different levels of prior knowledge fit to different types
    - of content structure
    - Different navigation tools and different levels of navigation support
      - not all learners can decide the navigation strategies by themselves



## Differences in knowledge domain

- Expert:
  - Formal training and experience in knowledge domain (Simmons & Lunetta, 1993)
  - Organized conceptual structure (Spires & Donley, 1998)
  - Representation of problems: emphasis on deep features (e.g. solution method) (Shertz & Weiser, 1982)
  - Global mental models

- Novice:
  - Little of no formal training in the domain
  - Chaotic and disorganized structure
  - Emphasis on surface features (e.g. application area)
  - Local mental models

## Information seeking strategy
(Jenkins et al, 2003)

- Expert: Depth-first strategy
  - Link on initial site
  - Following links provided by site
  - From another site to another
- Novice: Breadth-first strategy
  - Link on initial site
  - Go back to initial site
  - Following second link
  - Without exploring any links offered in depth



## Novices and experts in hypermedia
(Chen et al, 2004)

- Disorientation problems
  - Novices in the topic show more disorientation problems than experts
  - Expert's deep levels of understanding enable them to impose structure on the content (McDonald & Stevenson, 1998)
- Content structure
  - Novices benefit from **hierarchical structures** as it presents a conceptual structure of the material that help them to structure the text
  - Experts profit most from **flexible paths**

## Novices and experts in hypermedia
(Chen et al, 2004)

- Additional support for novices
  - Advisement on which sequence to follow (Shin et al, 1994)
  - Advance organizers (Shapiro, 1999): interactive overviews
  - Human support (Vansickle, 2000)
  - Graphical overviews (Muller-Kalthoff & Moller, 2004)
  - Structural cues (Hsu & Schwen, 2003)



# The learner's profile

- Who can benefit most from a web-based course?
  - Personality and attitudes
    - Tolerate ambiguity
    - Relatively free of anxiety
    - Field independent
    - Internal locus of control
    - Versatile learner able to effectively employ deep or surface learning approaches as necessary

  - Knowledge: Experts

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- Cognitive issues in using hypertext
- Individual differences
- Adaptive hypermedia systems



# Adaptive hypermedia systems

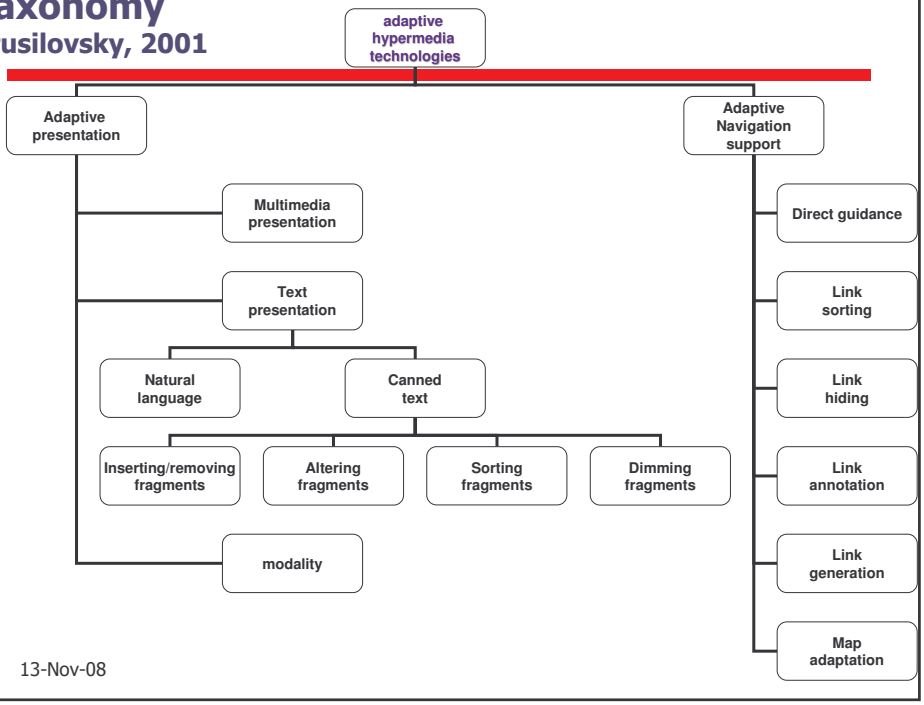
- Aim to help each individual learner by personalizing the functionality of the system
  - Learner's profile ⇨ adapt the instructional environment in a way that best suits the learner
- By building a **model of the user's**
  - Goals
  - Interests (e.g. adaptive bookmarking system)
  - Preferences
  - Knowledge
  - Personality, cognitive factors and learning styles (but need psychological tests to be assessed)
  - User's environment (user location and user platform, web server…)
- Uses this models throughout the interaction with the user in order to adapt to the **needs of the user**
  - E.g. different information
  - E.g. different links
- And to update the user's model

## Types of Adaptive hypermedia systems

- At content level:
  - **Adaptive presentation**
- At structure level:
  - **Adaptive navigation support**



## Taxonomy
### Brusilovsky, 2001



# Adaptive presentation

- Personalize **course content** to match with students' characteristics specified by the user model
  - Adaptive text
    - Canned text adaptation
      - Different users at different points in time may get different texts as a context of the same page
      - Inserting/removing text
      - Altering fragments
      - Sorting fragments
      - Dimming fragments
    - Natural language adaptation
  - Multimedia adaptation
    - Changing layout of the page (font size, color,…)
    - Changing type of media (accessibility)



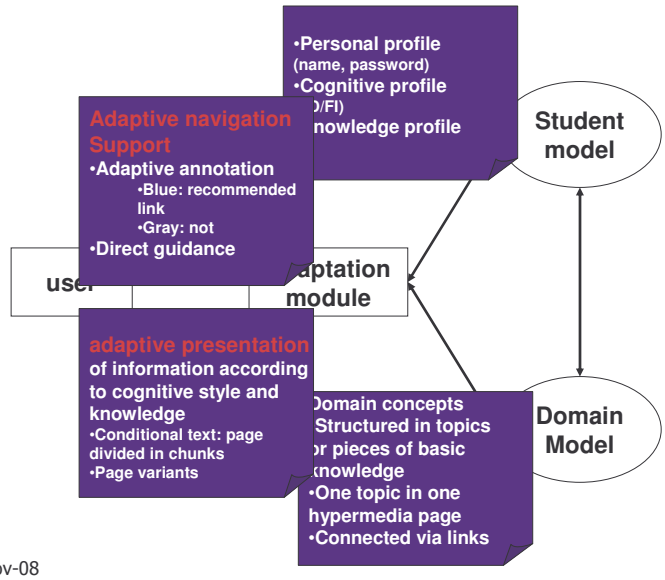
# Adaptive navigation support

- To help users to navigate and orientate in hyperspace by **adapting link presentation** to the characteristics of the user
- Techniques for adaptive navigation support (Brusilovksy, 2003)
  - Direct guidance: the system suggest the path to follow
  - Link adaptive annotation (checkmarks, links color…): supplies the user with additional information about the content behind the link
  - Link sorting
  - Link hiding
  - Generation-dynamic recommendation of relevant links
  - Map adaptation
- Help to find an effective path through the learning material
  - Especially to users with higher previous knowledge
    - Adaptive annotation (checkmarks, links color…)
    - Generation-dynamic recommendation of relevant links
  - "total novice" hypertext users prefer lineal path of navigation
    - Direct guidance
    - Hiding links

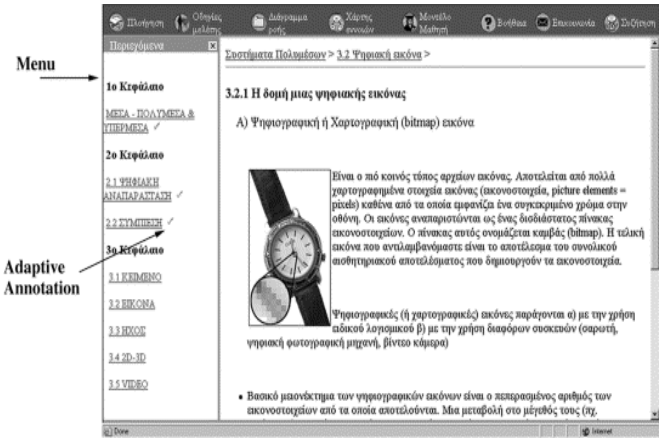
## AES-CS: Adaptive Education System based on Cognitive Styles (Triantafillou et al, 2003)

- To support the course "multimedia technology systems"
- AES-CS adapts to
  - Learning style: FD/FI
    - FD
      - less likely to impose a meaningful organization on a field that lacks structure
      - Less able to learn when cues are not available
    - FI prefer to impose their own structure on information
  - Level of knowledge





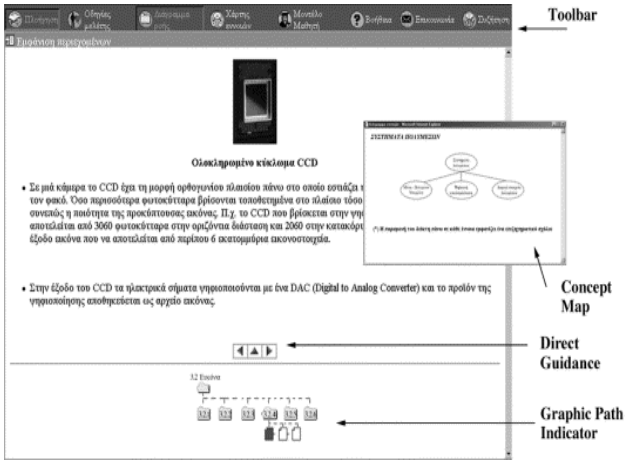
# Field Independence (FI) learners




System screen with the initial adaptation for Field Independence (FI) learners

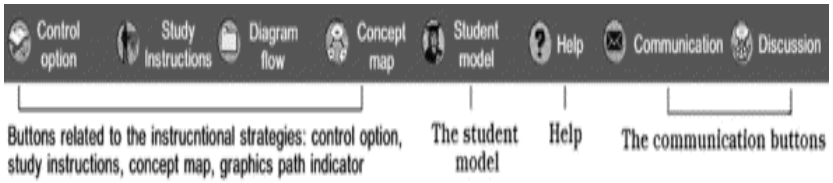


# Field dependence (FD) learners




System screen with the initial adaptation for Field dependence (FD) learners

# Adaptation flexibility




- Users are not simply FD/FI but a combination of both characteristics
- Users learn and change
- Users should use a combination of instructional strategies in order to accommodate their needs

- AES-CS allows users to modify it: Toolbar
  - Control: learner/program
  - Feedback: minimum/maximum
  - Instructions: yes/not
  - Concept map: yes/not
  - Graphic path indicator: yes/not