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Technology As Dynamic Artifact and Communication Medium

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MAGIC

- Media And Graphics Interdisciplinary Centre
- Cognitive Science of human interaction with technological tools, media, & environments
- Human-centred design of new technologies
- Co-evolution of institution and technology
- Collaboration with SFU GRUVI
- New Inst. For Computing, Information and Cognitive Systems

- "Human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought"

Man-Computer Symbiosis, J.C.R. Licklider 1960

Ergonomic sinkhole

- Structure process and information
  - Categories, hierarchies, & sequences
  - Lock-step processes and rigid categories
  - Hidden information is most important for innovation
- " We shape our tools, and then our tools shape us" Vygotski
- Reinforcing structures and processes make it hard to "think outside the box"
- Changing processes just shifts the problem
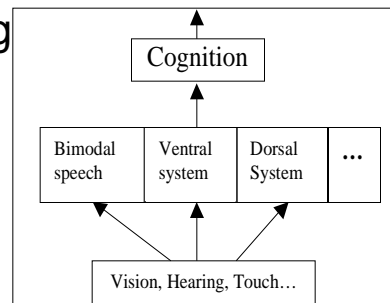
Perceptual Cognition

- Theoretical analysis of perception, action, and problem solving

- "Things that make us smart" Thinking tools and artifacts

  – Physical & virtual models

  – Notation systems, sketches

  – Whiteboards

  – Kitchen tables

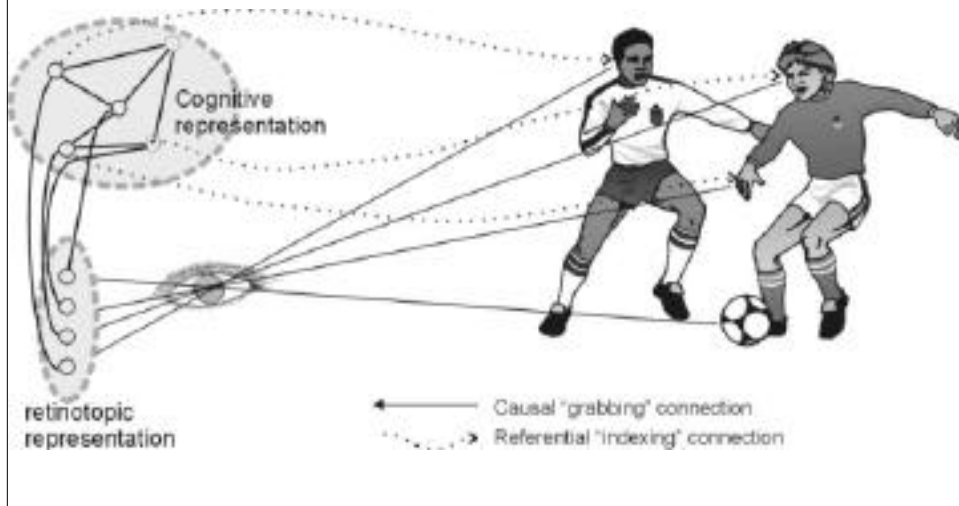# One input, many processes

- Intuitions about thinking

  – Fails at low levels

- Cognitive Architecture

  – Multiple brain areas

  – Interconnected

  – Informationally encapsulated

  – Multimodal inputs, parsed from scene and fused

Cognition

| Bimodal speech | Ventral system | Dorsal System | ... |

Vision, Hearing, Touch…

Indexical cognition

FINST demo

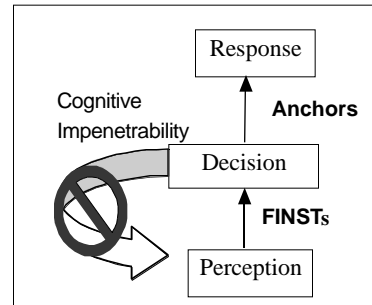**THE UNIVERSITY OF BRITISH COLUMBIA**

FINST 2

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FINST 3

"FINSTs... make thoughts true"

- Perception
  - "Hotlink" tokens
  - Drawn to salient events
  - Object-centred, "sticky"
  - Visual routines
  - Finite number ~ 4

- Cognition
  - Maintain object history
  - Implicit memory of object associations
  - Sparse cognitive representation
  - Just-in-time delivery of information
  - Atom of intentionality

Response

Cognitive
Impenetrability

Anchors

Decision

FINSTs

Perception

Inseparability of Mind & World

- Embodied cognition-- mind/body
- Situated cognition-- mind/world
- Distributed cognition-- mind/mind
- Ecological theories (Vygotski, Luria, Bateson, Gibson) can be linked to sensory phenomena and inform interaction design

CogSci inspired HCI

- Thinking tools
  - **Indexical interface (vs. icon, symbol)**
  - **Format-independent** visual placeholders for knowledge
  - **Anchoring** concepts in data (e.g. URLs link to underlying evidence)
- Manipulation of placeholders reflects
  - **Information selection, acquisition**-- Web, local sources, experts
  - **Transformation into knowledge**-- Spatial (re)arrangements:

CogSci aspects

- Gestalt groupings = visual analog of thought
- Pattern discovery, concept clustering and chunking builds and reflects expertise
- Epistemic actions: Operations in the world that are taken specifically to change the actor/operator's mental representation
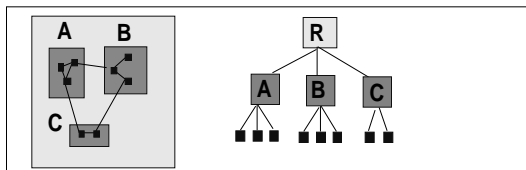
ThoughtShare

Based on a software prototype developed at Simon Fraser University to support the evolution of users' understanding through the manipulation of information in the form of graphical placeholders that represent particular information clusters because they point to them, and can display them on demand in a browser window.
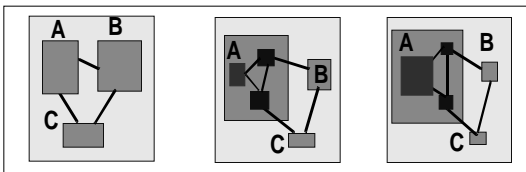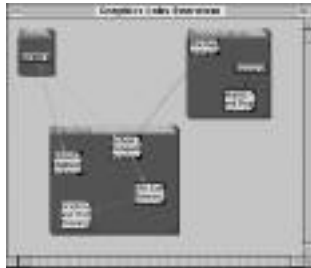

Aspects of the CZ Display

- Hierarchy of items and clusters
- Multiple levels are viewable
- Continuous zoom
- Layout algorithm

Web -based knowledge work
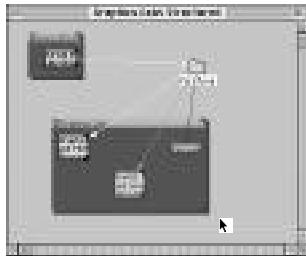
CZWeb creates a clickable index for each Web page visited at an open location.

If space is at a premium, CZWeb allows items to change size and location to make room for new or expanded items.

The result is an environment for decision evolution through flexible, spatial organization of information.

User Test results

User tests showed it aided users to perform tasks combining information from different areas of the Web (HCI International 1997)

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ThoughtShare

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Next steps

- Visual languages with indexical and symbolic operations
  - "Tribal languages"
  - Types and Relationships
  - Syntax that reflects cognitive operations
    - Proximity
    - Collinearity
    - Containment
    - Chunking

Escaping the sinkhole

- Support knowledge creation and capture
  - Focuses on innovation, breaking the rules
  - Supports the thinking process
  - Captures the results
- Support communication in collaboration
  - Natural patterns of communication
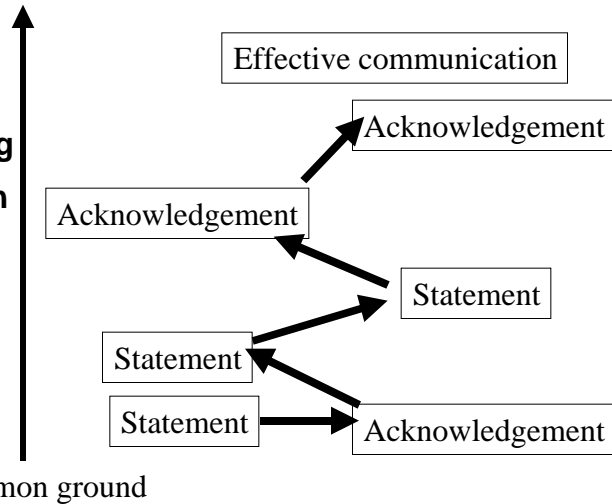 - Metacognition support

Distributed Cognition

- Communication as a **Joint action**
- First goal is building metarepresentation: **Grounding**
- Theory of Mind Module (ToMM)
  - Neural structure
  - Matures ~4-5 years
  - Allows meta-representation
  - Impaired in autism

Communication patterns

– **Adjacency pairs confirm understanding**

– **Metacognition builds shared referents**

– **Conversation advances in ladders of meaning** Common ground

Effective communication

Acknowledgement

Acknowledgement

Statement

Statement

Statement

Acknowledgement

Groupware design goals

- Group actions of a participant in different environments and over time
- Support awareness of participants and their roles
- Support "grounding" patterns
  - Sequences of information and participants
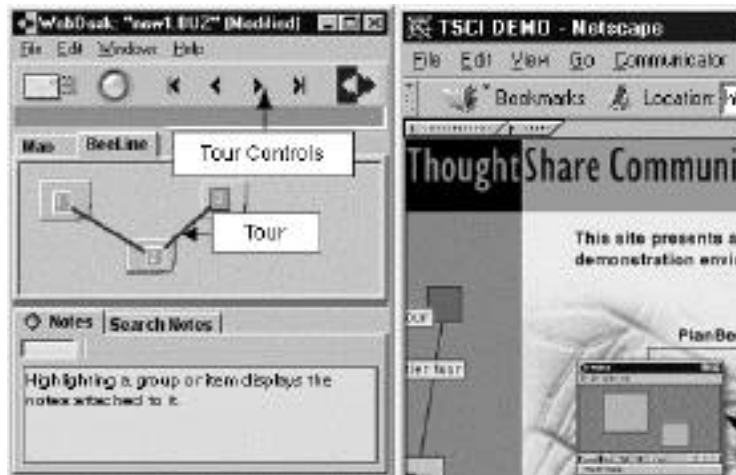 - Confirmation of understanding
  - Advancement
  - Annotation

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ThoughtShare

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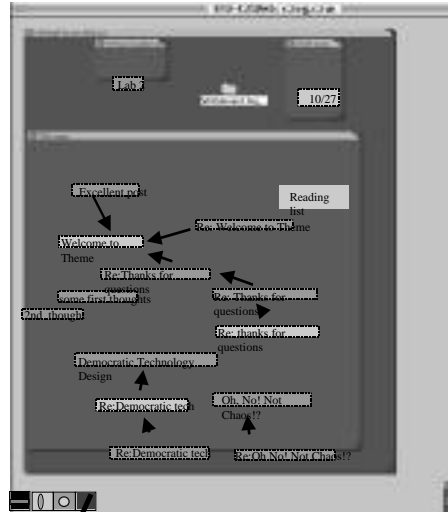# Sequencing for linear overview
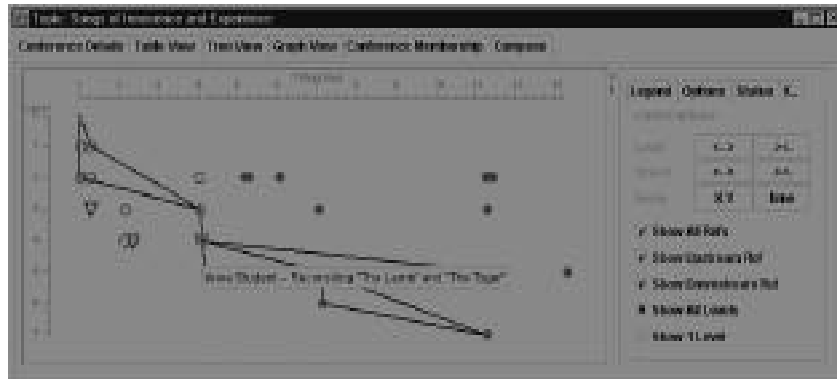
CZ approach to Groupware

- Personal icon gives visual cues as to who is present
- Icon highlights all productions of that user
- Multiple referents/message
- CZ "springs" move most referenced messages inward
- Messages evolve into concept map
- Drill down from concept map to find authors

Visualization of communication
patterns

- Multiple referents/message
- Argument level x time at a glance
- Time sliders, level of argument, icons for message types etc.

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Collaboration questions

- Does a graphical analog of a collaborator's thought processes give us more insight into the content of their mind-- thought processes and beliefs?
- Does it give us more insight into the nature of those processes?
- Can TOMM learn a visual language?

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Mind/world questions

- Can we develop virtual environments specifically for mind-in-world thinking?
  - 2-1/2D
  - 3D+
- How complex can the behaviours of these concept/objects be?
  - Intelligent
  - Attentive
- Industrial design-- Vygotski again!

Collaborators:
Kelly Booth
John Dill
Zenon Pylyshyn

Research support
PRECARN
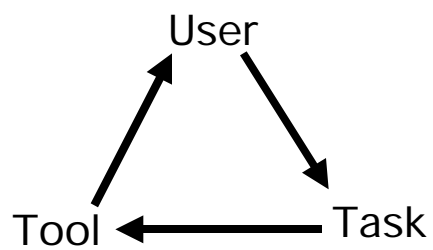
IRIS NCE
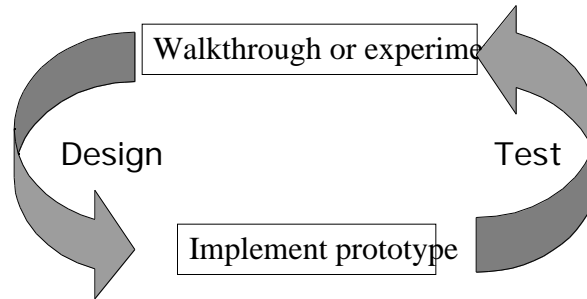
Telelearning NCE

MAGIC endowment

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Ergonomic HCI model

User

Tool ← Task

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Iterative development cycle

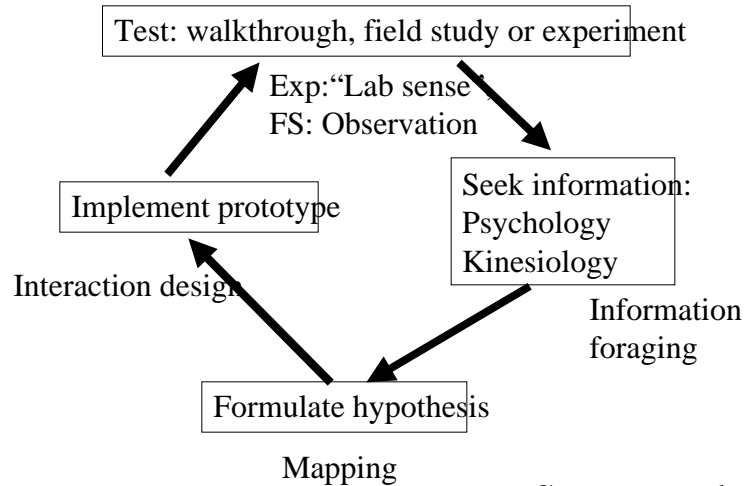Walkthrough or experime[nt]

Design

Test

Implement prototype

Spiral with increasing detail and test specifici[ty]

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Reflective Practitioner Model

Test: walkthrough, field study or experiment

Exp:"Lab sense"
FS: Observation

Implement prototype

Seek information:
Psychology
Kinesiology

Interaction design

Information
foraging

Formulate hypothesis

Mapping

Start anywhere!

Research conclusions

- Isolated human mind is pretty well useless...

- …when the situation contains uncertainty, requires remembering things, involves other people, evolves over time in a non-linear fashion, or has more than 6 factors, 4 of which must remain static.

Mental biases and bottlenecks

- Mental model limitations
- Reasoning about uncertainty
- Predictions of change over time
- Memory limitations and biases
- Predicting the actions of another
- Decision-stage bias

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Limits to mental models

- Limited to 6 items

- Only 2 can be active

- Superficial similarities trigger

  analogical reasoning

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Reasoning about uncertainty

- Base rate neglect

- Logic limits reasoning under

  uncertainty

- Probability matching

Predicting change over time

- Predictions of change over time
  - Systematic errors in predicting change over time
- Memory effects
  - Primacy/recency
  - Reconstructed memories
  - Aging effects

Decision-stage errors

- Social/interpersonal biases
  - Situational influences underestimated (fundamental attribution error)
  - Cultural differences underestimated
- Decision-stage errors
  - Confirmation bias
  - Cognitive structure/dissonance
  - End effects

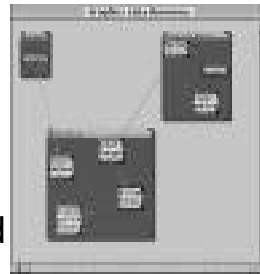# Extending cognitive processes

- Visual metaphors
  - Whiteboards
  - Napkins
  - Kitchen tables, not desktops
- Perceptual inference
  - Information visualization environments
  - Concept mapping
  - ThoughtShare PlanBee

FINSTs in CZWeb

- Multiple FINSTs allow indexing of several clusters
- Index links to object history, so users should know what page is pointed to
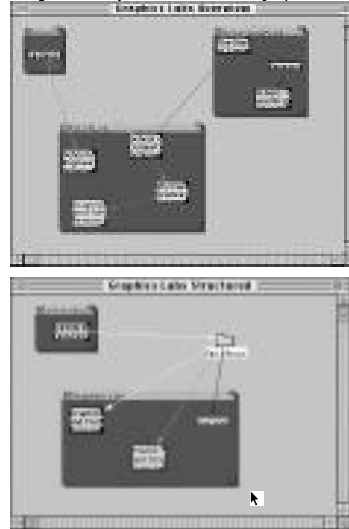- Indices are sticky, so they track as the display changes

Restrictions on display changes

- Nodes visibly move to their new location at a moderate speed
- Graph representation allows user to cluster and hide individual nodes to keep number of display items small
- Gestalt groupings are maintained

How to break CZWeb

- Redraw nodes in new locations rather than moving them so history is lost
- Let number of items get much larger than number of FINSTs
- Allow nodes to frequently change qualitative spatial relationships (e.g. inside-of)