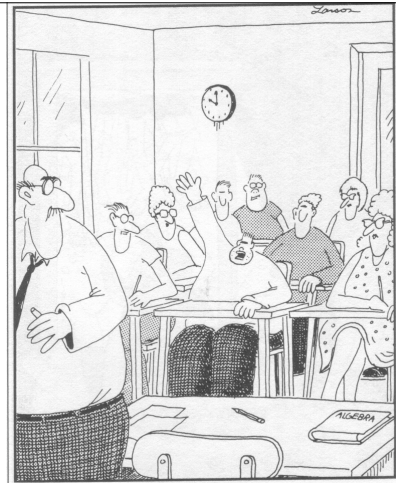# What exactly are your learners learning?

Applying mental model elicitation techniques to enhance assessment of your courses and programs.

Barry R. Hill
Lebanon Valley College

"Mr. Osborne, may I be excused? My brain is full."

What are they learning?

- Individuals process information and experiences in unique ways based on prior knowledge, experiences, cognitive abilities, etc.
- Twenty students will leave your class with twenty variations of what you covered.
- Issue: memorization vs higher-level organization of content required for advanced performance, problem-solving, and transfer.

Traditional assessment

- Traditional methods such as exams don't often get at these higher level skills and understandings.
- Exams too often:
  - prompt responses based on instructor's organization/presentation of material.
  - are affected by environment of fear/tension due to grades.
  - lead toward strategic memorization, not deep thinking and learning.

"Many examinations may capture the students' ability to take certain kinds of tests, but reflect little about the way students think." Ken Bain

Alternative assessment

- Need to find out *from the individual* how they perceive that subject and what they can do with it - much richer.
- So, the trick is to peer into their brain to "see" how they've structured the content.

Mental models

Mental models

- The way an individual organizes information and concepts about a subject is called a *mental model.*

- Each individual's model of a subject will vary to some degree.

- These models change over time through experiences, failure, success, etc.

- They are "*the models people have of themselves, others, the environment, and the things they interact with.*" Donald Norman

Examples

- Operating a car
- Thermostat
- Restaurants
- Music history
- Social responsibility
- Include your own field here

Application to education

- In education, we want to ensure students are "getting it" in our classes.

- Just because they score a 98 doesn't mean they really understand it.

- Mental model analysis can reveal how they perceive the material, thereby informing instructional design of the course.

Levels of knowledge in a mental model

- Content (declarative - knowing stuff)
- Structural (relational - connecting stuff)
- Procedural (applying to actual work)
  - *Structural Knowledge: Techniques for representing, conveying, and acquiring knowledge.* Jonassen, Beissner, Yacci.

Instructional goals

- We want students to think similar to an expert in the field.
  - Accurate information
  - Organized in a meaningful way
  - Able to apply knowledge in performance
 - Can transfer knowledge to new situations

Expert vs novice

- Compare mental models of experts in the field to student models.
- Expert can be the instructor, practicing professionals, etc.
- Presumably the expert model is the goal for instruction, so examining student models reveals issues that can inform course instructional design.

Methods for eliciting mental models

- Various methods have been utilized in many fields.
  - Concept mapping
  - Procedural analysis (think-aloud)
  - Card sort
  - others...

Concept mapping is most familiar. Drawback is that participant must first learn how to create a map.
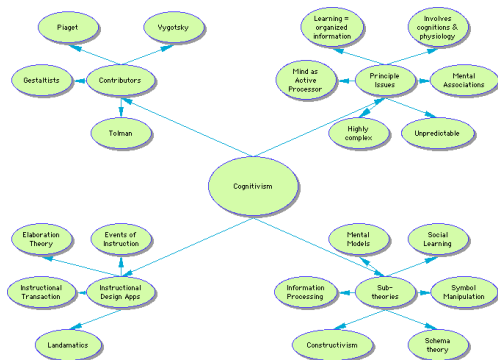
Think-aloud procedure common in cognitive psychology/education studies. Very time consuming, but effective.
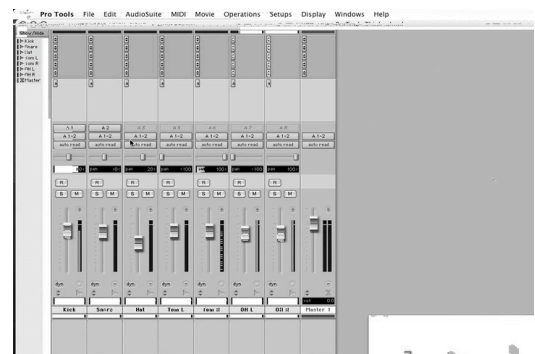
This is a video of a participant completing a task in the software. All their actions and spoken thoughts are then transcribed and analyzed.

Card sorts

- This method involves participants sorting terms into piles that seem to go together.
- Designed to capture how an individual organizes concepts about a particular subject.
- Sorts reveal areas of deficiency and inaccuracy (missing information, wrong connections between concepts).
- Can also reveal level of understanding.

Sort procedure

- Investigator develops a list of terms/concepts significant to a particular subject.
- Participants sort these terms by placing them into piles of relevance.
- Terms that seem most similar go into a pile.
- Piles are determined, and labeled, by the participant based on whatever criteria they want to use.
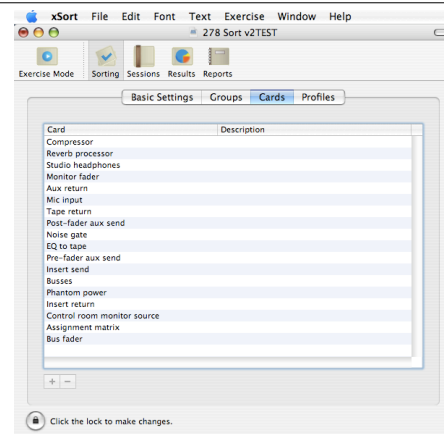- Can use note cards or software.

You try

Chevrolet	Honda
Ford	Volvo
Volkswagon	Toyota
Mazda	Chrysler
Audi	Saturn

Now try this

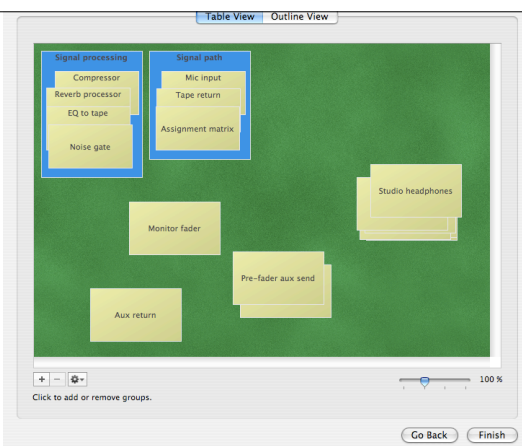|	
Chevrolet	Honda
Lexus	Volvo
Volkswagon	Toyota
BMW	Chrysler
Dodge	Jaguar

Card sort software

- There are a few software or web-based packages available for PC and Mac.
  - See handout for resource websites.
- xSort was used for these examples.


Creating the terms (cards) in xSort software.

This is the screen where cards are sorted.

Analysis methods

- Manually review the sort results (piles).
  - Many argue this is the best way.
- Process cognitive maps in software that visually represent data patterns.
- The goal is to identify patterns or trends in how users sorted the terms.
- Remember - this is not a grading exercise.
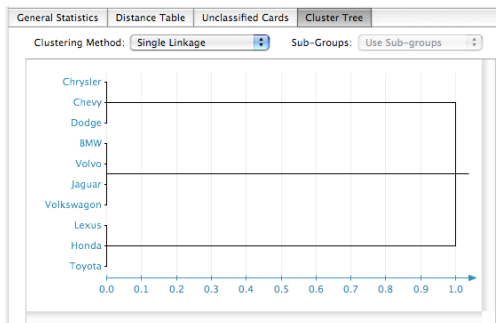
Manually reviewing piles
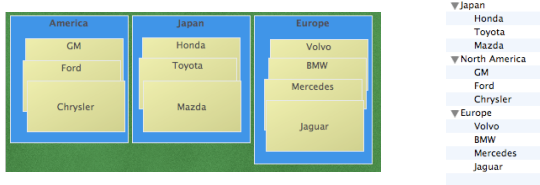
This sort organizes the auto makers by country/region of origin.

Processing results in software

- Using statistics software, we can create cognitive maps, or visual representations of the data which more easily show patterns.
- Three primary methods:
  - Cluster analysis
  - Multidimensional scaling (MDS)
  - Microsoft Excel

Cluster analysis

- Single session sorted by region of manufacturer.
- Easy to see which cards were in the same piles.
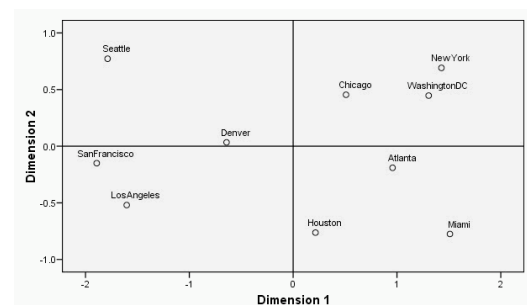
Cluster analysis
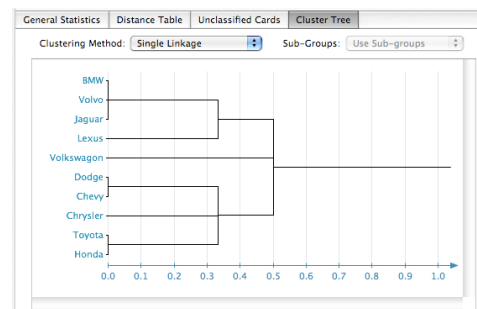
Multiple sessions sorted by region and price

Multidimensional scaling

- Mathematical model that produces cognitive maps based on distance (similarity) data.
- Distance data comes from whether terms were placed in same or different piles.
- The map shows spatial representation of these distances along two (or more) dimensions.
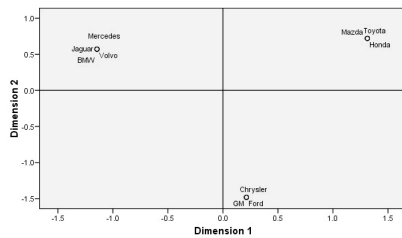
Simple MDS example

These resulting dimensions provide clues as to what your participants are thinking about the relationships among the concepts. Can you find a pattern in this map?

Auto sort map

Auto Manufacturers (sorted by country/region)
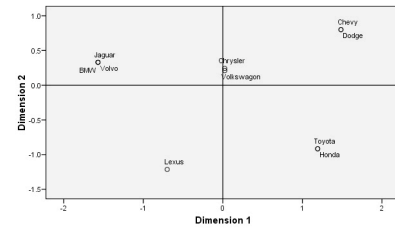
Euclidean distance model

Each pile of terms is distant from the others because they were in distinct piles.
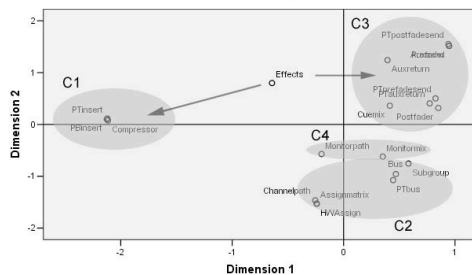
Multiple auto sorts mixed by country & price

Auto Manufacturers (multiple sorts by location and price)

Euclidean distance model

This map shows that Lexus was placed by some in the BMW/Jag pile, but in the Toyota/Honda pile by others.

Complex MDS example

Analysis markings show clusters of terms that resulted from multiple sorts - less clearly defined due to people sorting differently.

Example studies

- Recording engineering
  - Goal is understanding recording systems, which are complex in terms of functions and operations.
  - Students must have a correct model in order to transfer to a more complex system.
  - Expert-novice comparison
  - Used to inform instructional effectiveness of degree program curriculum design.

Simple recording system
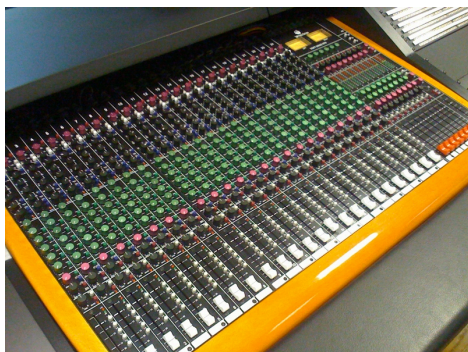
Complex system

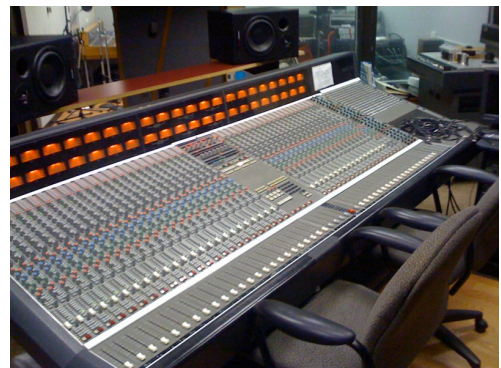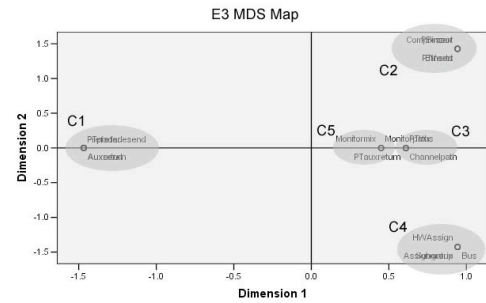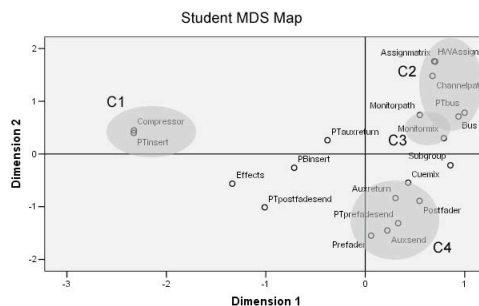## Software recording system

Expert sort

Analysis markings show distinct clusters of terms that resulted from this single expert sort.

Student sort

This composite student sort is messier and ill-defined compared to the expert sort.

Music history

- First semester music history class
- Typical chronological sequence, content-based
- Fairly basic level of organization - in this case sorting terms by time periods.
- Could be expanded for higher-level conceptual relationships.

Music history results

- 50% of the students sorted similar to the expert sort completed by the instructor.
  - In this case, by time periods, which demonstrated broad connections in the material.
- Several sorted by a lower-level conceptual organization.
  - Definitions-based organization. Showed lack of ability to make broader, more meaningful connections.

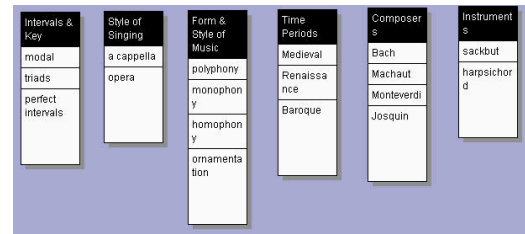## History results cont.

- The most common "mistake" was placing composers in the wrong time period.
- Students were generally able, however, to place other relevant terms into correct time periods.
- Instructor now realizes that although students seemed to grasp the literature, more emphasis must be placed on composers.
- She was surprised a bit by the results--would not have known these issues existed.
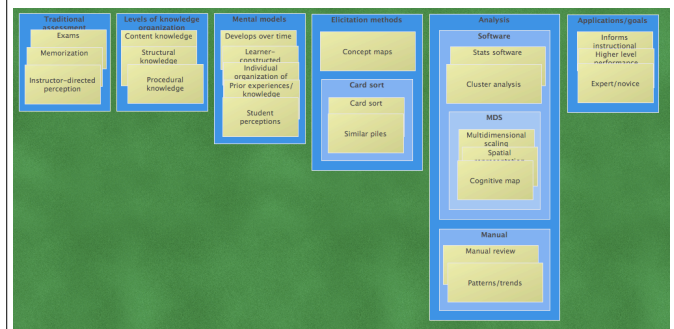
"Correct" sort

Medieval period (9th- 14 century)
modal
a cappella
Medieval
sackbut
monophony
perfect intervals

Renaissance period (15th-16th century)
polyphony
triads
Renaissance
Machaut
Monteverdi
Josquin

Baroque Period (1600-1750)
Bach
opera
harpsichord
Baroque
homophony
ornamentation

Lower-level organization
(definitions-based)

Intervals & Key
modal
triads
perfect intervals

Style of Singing
a cappella
opera

Form & Style of Music
polyphony
monophony
homophony
ornamentation

Time Periods
Medieval
Renaissance
Baroque

Composers
Bach
Machaut
Monteverdi
Josquin

Instruments
sackbut
harpsichord

Another for you to try

- Sort the terms on the cards that seem most similar into piles.
- http://lvccetl.optimalsort.com/hillmmdemo

My sort for this demo

How to develop a sort

- Select terms/concepts relevant to some aspect you are investigating.
- Avoid a list of terms that are widely different-- they should represent some cohesive aspect of the subject.
- These terms could be from one unit in your course, the entire course, or even an entire program of study at the institution.
- Sort the terms yourself as you develop the list.

Levels of abstraction

- Concrete, objective terms that have "correct" ways to sort
  - ex: music history composers/genres, operation of a system
- More abstract, higher-level concepts that provide multiple answers and perspectives
  - Solving a business problem, opinions on current events, why historical events happened such as the Civil War

Have an open mind

- Keep in mind that subjects that seem concrete and straightforward can be viewed quite differently, even among experts, but especially among novices.
    - That's why this type of assessment is so valuable--to detect those differences in order to adjust instruction.

Develop a sort for your course or program

Questions?

- Feel free to contact me:

    Barry R. Hill
    Lebanon Valley College
    hill@lvc.edu
    www.mentalmodelassessment.org
    http://cetl.lvc.edu/cetl_blog
    http://personal.lvc.edu/~hill