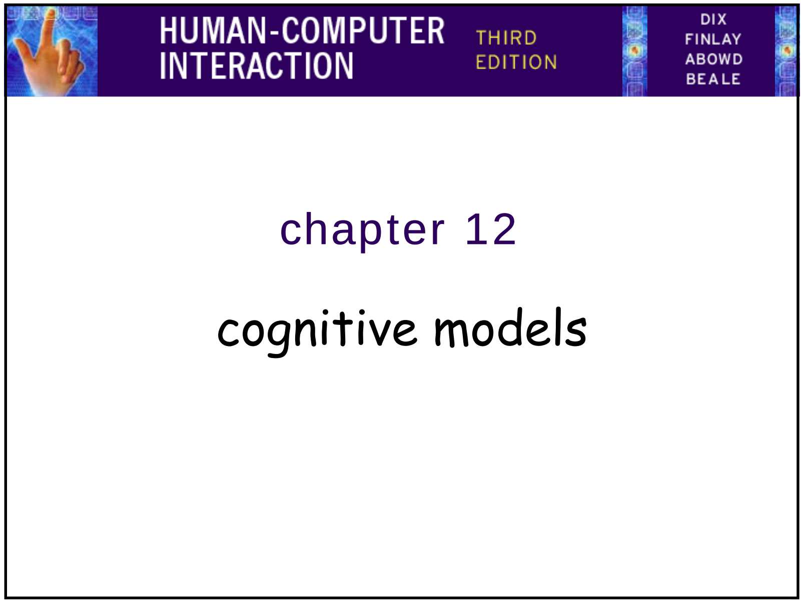
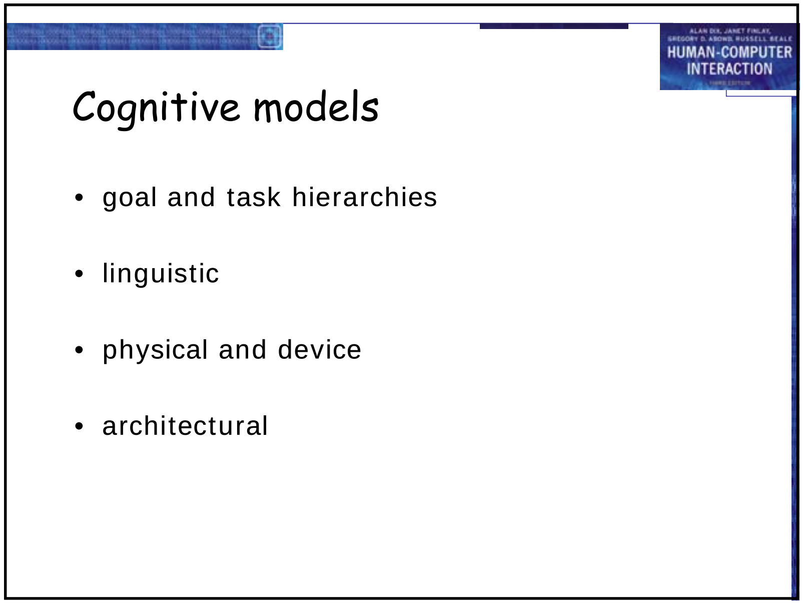

HUMAN-COMPUTER INTERACTION THIRD EDITION

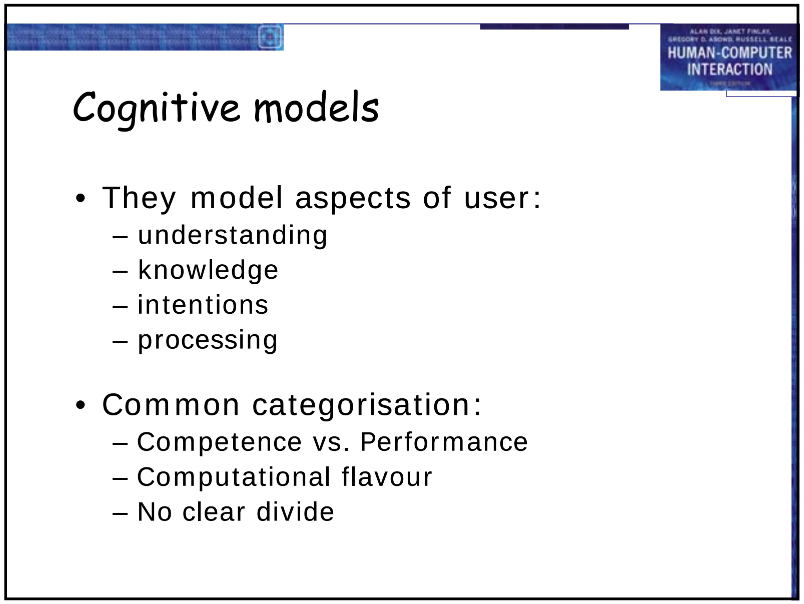
DIX FINLAY ABOWD BEALE

chapter 12

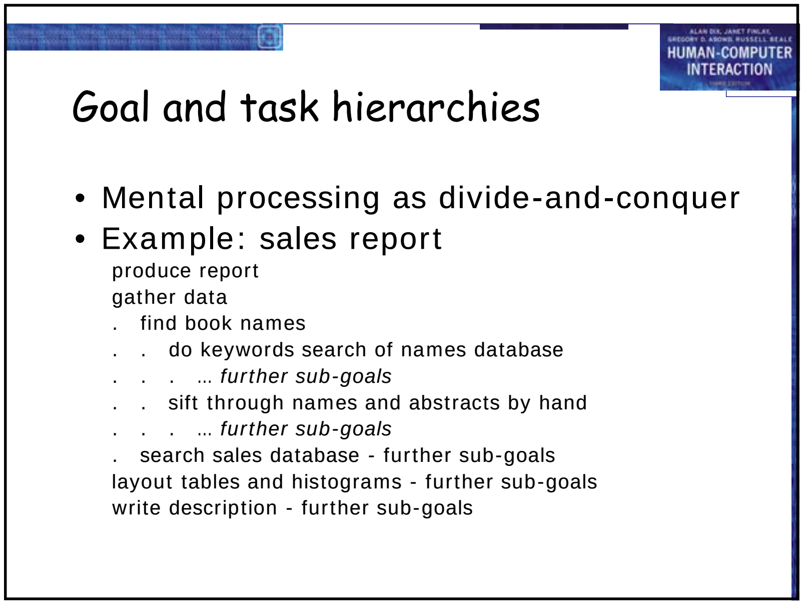
cognitive models


Cognitive models

- goal and task hierarchies
- linguistic
- physical and device
- architectural

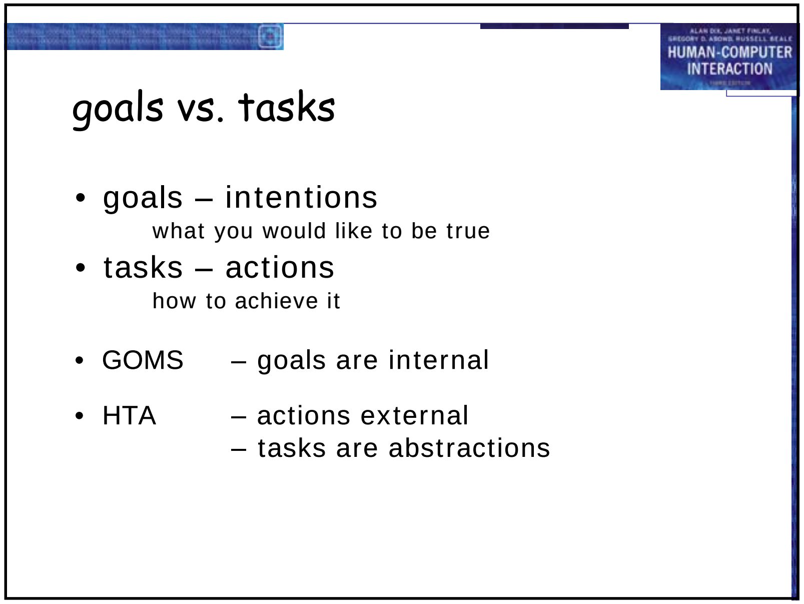

Cognitive models

- They model aspects of user:
  - understanding
  - knowledge
  - intentions
  - processing
- Common categorisation:
  - Competence vs. Performance
  - Computational flavour
  - No clear divide


Goal and task hierarchies

- Mental processing as divide-and-conquer
- Example: sales report

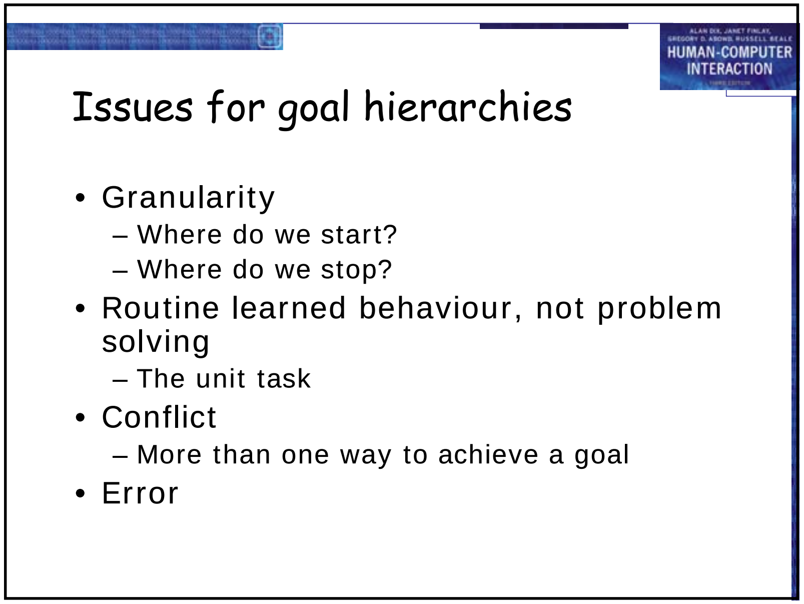
produce report
gather data
. find book names
. . do keywords search of names database
. . . ... *further sub-goals*
. . sift through names and abstracts by hand
. . . ... *further sub-goals*
. search sales database - further sub-goals
layout tables and histograms - further sub-goals
write description - further sub-goals



goals vs. tasks

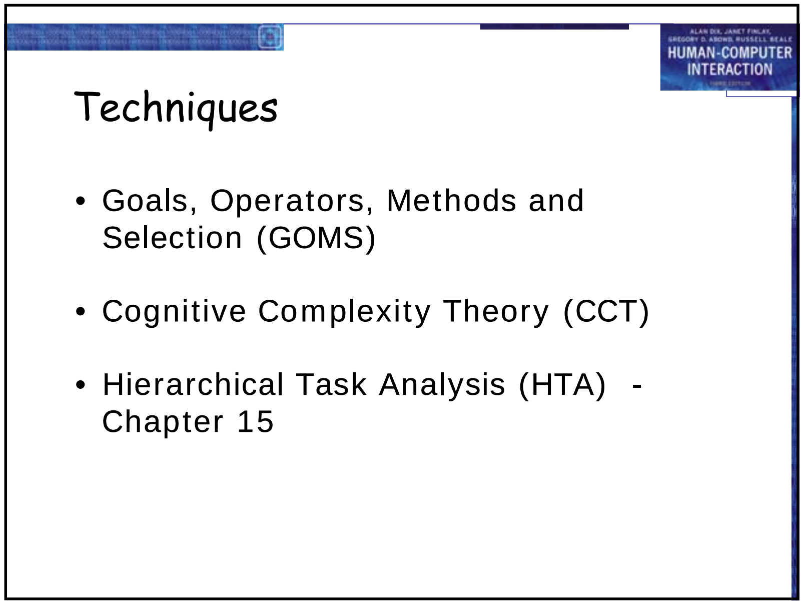
- goals – intentions
  what you would like to be true
- tasks – actions
  how to achieve it

- GOMS – goals are internal
- HTA – actions external
  – tasks are abstractions



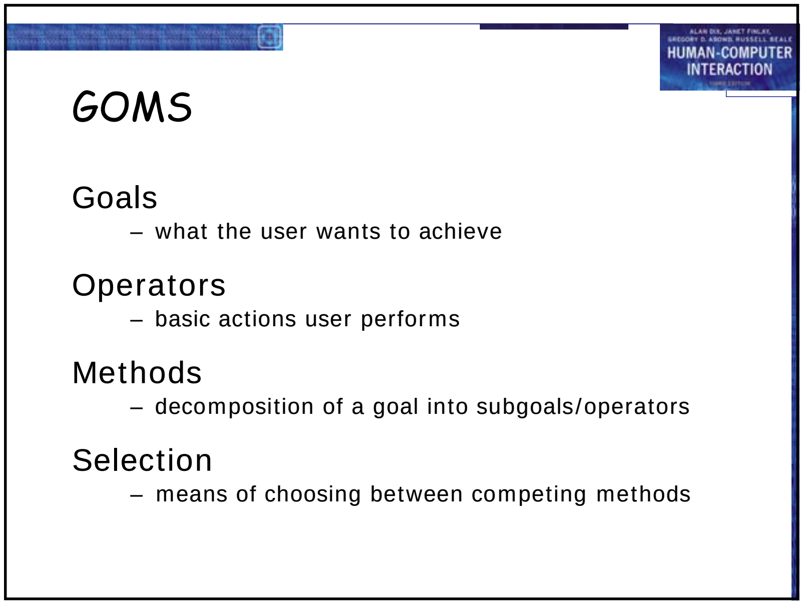
Issues for goal hierarchies

- Granularity
  - Where do we start?
  - Where do we stop?
- Routine learned behaviour, not problem solving
  - The unit task
- Conflict
  - More than one way to achieve a goal
- Error



Techniques

- Goals, Operators, Methods and Selection (GOMS)
- Cognitive Complexity Theory (CCT)
- Hierarchical Task Analysis (HTA) - Chapter 15



GOMS

Goals
- what the user wants to achieve

Operators
- basic actions user performs

Methods
- decomposition of a goal into subgoals/operators

Selection
- means of choosing between competing methods

GOMS example

```
GOAL: CLOSE-WINDOW
.    [select GOAL: USE-MENU-METHOD
.            .    MOVE-MOUSE-TO-FILE-MENU
.            .    PULL-DOWN-FILE-MENU
.            .    CLICK-OVER-CLOSE-OPTION
            GOAL: USE-CTRL-W-METHOD
.            .    PRESS-CONTROL-W-KEYS]

For a particular user:

   Rule 1: Select USE-MENU-METHOD unless another
           rule applies
   Rule 2: If the application is GAME,
           select CTRL-W-METHOD
```

GOMS exercise

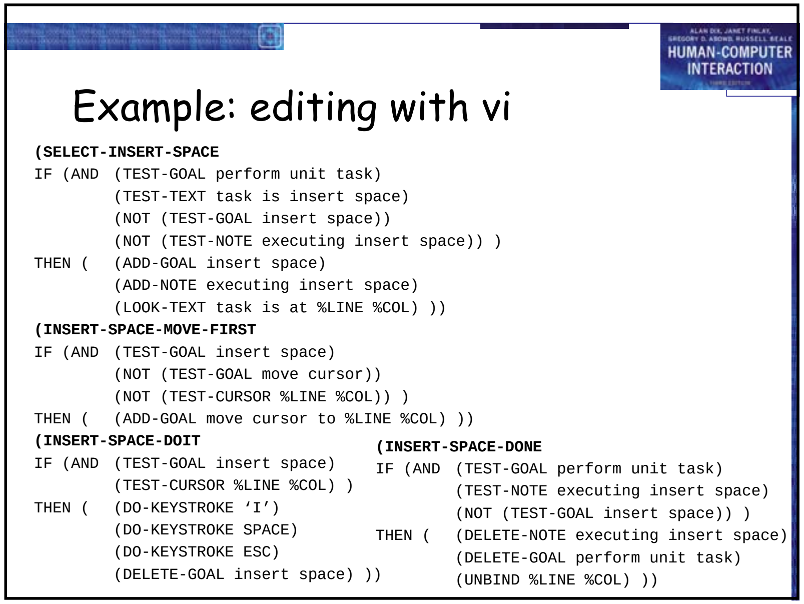
Delete a file using Windows Explorer

GOMS exercise answer

```
GOAL:    DELETE-FILE
.        LOCATE-FILE
.        MOVE-CURSOR-OVER-FILE
.        [SELECT GOAL:    DRAG-TO-TRASH-METHOD
.                .        HOLD-MOUSE-BUTTON-DOWN
.                .        LOCATE-TRASH-ICON
.                .        MOVE-CURSOR-TO-TRASH-ICON
.                .        VERIFY-TRASH-IS-REVERSE-VIDEO
.                .        RELEASE-MOUSE-BUTTON
.                GOAL:    USE-DELETE-KEY-METHOD
.                .        CLICK-ON-FILE
.                .        PRESS-DELETE-KEY
.                .        LOCATE-CONFIRM-YES
.                .        [SELECT  GOAL:    CONFIRM-YES-KEYBOARD-METHOD
.                .                 .        PRESS-Y-KEY
.                .                 GOAL:    CONFIRM-YES-MOUSE-METHOD
.                .                 .        MOVE-CURSOR-OVER-YES-BUTTON
.                .                 .        CLICK-ON-YES-BUTTON]
.                GOAL:    USE-RIGHT-CLICK-OPTION-METHOD
.                .        RIGHT-CLICK-ON-FILE-AND-HOLD-DOWN
.                .        LOCATE-DELETE-OPTION
.                .        MOVE-CURSOR-OVER-DELETE-OPTION
.                .        RELEASE-MOUSE-BUTTON
.                .        LOCATE-CONFIRM-YES
.                .        …
```

Cognitive Complexity Theory

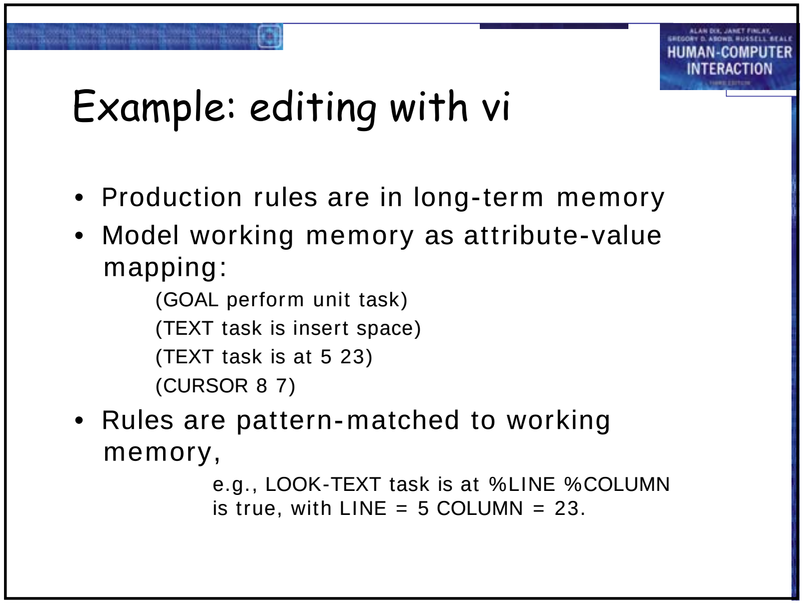
- Two parallel descriptions:
  - User production rules
  - Device generalised transition networks
- Production rules are of the form:
  - if condition then action
- Transition networks covered under dialogue models



Example: editing with vi

```
(SELECT-INSERT-SPACE
IF (AND  (TEST-GOAL perform unit task)
         (TEST-TEXT task is insert space)
         (NOT (TEST-GOAL insert space))
         (NOT (TEST-NOTE executing insert space)) )
THEN (   (ADD-GOAL insert space)
         (ADD-NOTE executing insert space)
         (LOOK-TEXT task is at %LINE %COL) ))
(INSERT-SPACE-MOVE-FIRST
IF (AND  (TEST-GOAL insert space)
         (NOT (TEST-GOAL move cursor))
         (NOT (TEST-CURSOR %LINE %COL)) )
THEN (   (ADD-GOAL move cursor to %LINE %COL) ))
(INSERT-SPACE-DOIT
IF (AND  (TEST-GOAL insert space)
         (TEST-CURSOR %LINE %COL) )
THEN (   (DO-KEYSTROKE 'I')
         (DO-KEYSTROKE SPACE)
         (DO-KEYSTROKE ESC)
         (DELETE-GOAL insert space) ))
```

```
(INSERT-SPACE-DONE
IF (AND  (TEST-GOAL perform unit task)
         (TEST-NOTE executing insert space)
         (NOT (TEST-GOAL insert space)) )
THEN (   (DELETE-NOTE executing insert space)
         (DELETE-GOAL perform unit task)
         (UNBIND %LINE %COL) ))
```



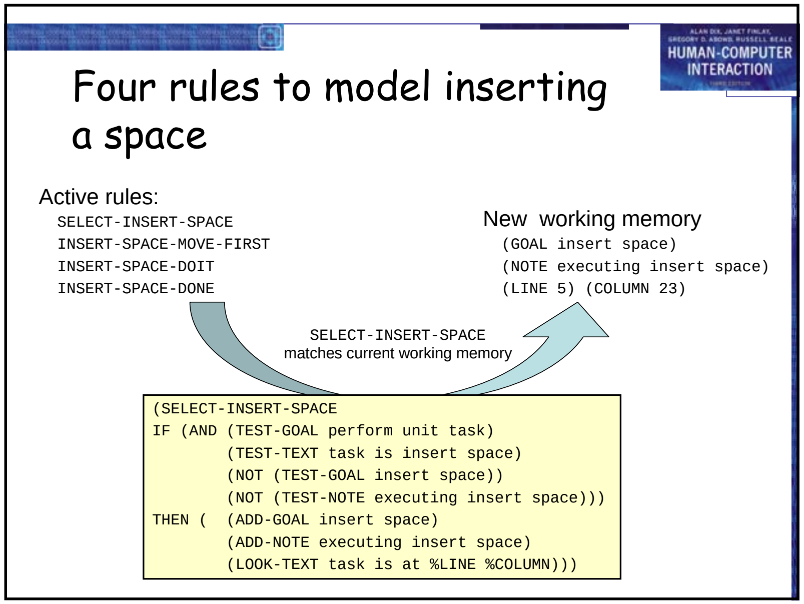
Example: editing with vi

- Production rules are in long-term memory
- Model working memory as attribute-value mapping:

  (GOAL perform unit task)
  (TEXT task is insert space)
  (TEXT task is at 5 23)
  (CURSOR 8 7)

- Rules are pattern-matched to working memory,

  e.g., LOOK-TEXT task is at %LINE %COLUMN
  is true, with LINE = 5 COLUMN = 23.



Four rules to model inserting a space

Active rules:

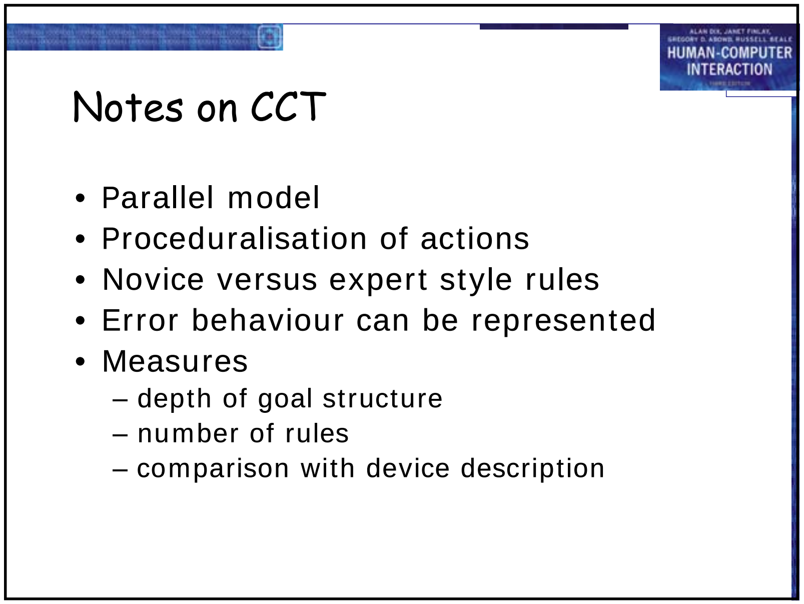
```
SELECT-INSERT-SPACE
INSERT-SPACE-MOVE-FIRST
INSERT-SPACE-DOIT
INSERT-SPACE-DONE
```

New working memory

```
(GOAL insert space)
(NOTE executing insert space)
(LINE 5) (COLUMN 23)
```

SELECT-INSERT-SPACE
matches current working memory

```
(SELECT-INSERT-SPACE
IF (AND (TEST-GOAL perform unit task)
        (TEST-TEXT task is insert space)
        (NOT (TEST-GOAL insert space))
        (NOT (TEST-NOTE executing insert space)))
THEN (  (ADD-GOAL insert space)
        (ADD-NOTE executing insert space)
        (LOOK-TEXT task is at %LINE %COLUMN)))
```



Notes on CCT

- Parallel model
- Proceduralisation of actions
- Novice versus expert style rules
- Error behaviour can be represented
- Measures
  - – depth of goal structure
  - – number of rules
  - – comparison with device description

Problems with goal hierarchies

- a post hoc technique
- expert versus novice
- How cognitive are they?

Linguistic notations

- Understanding the user's behaviour and cognitive difficulty based on analysis of language between user and system.
- Similar in emphasis to dialogue models
- Backus–Naur Form (BNF)
- Task–Action Grammar (TAG)

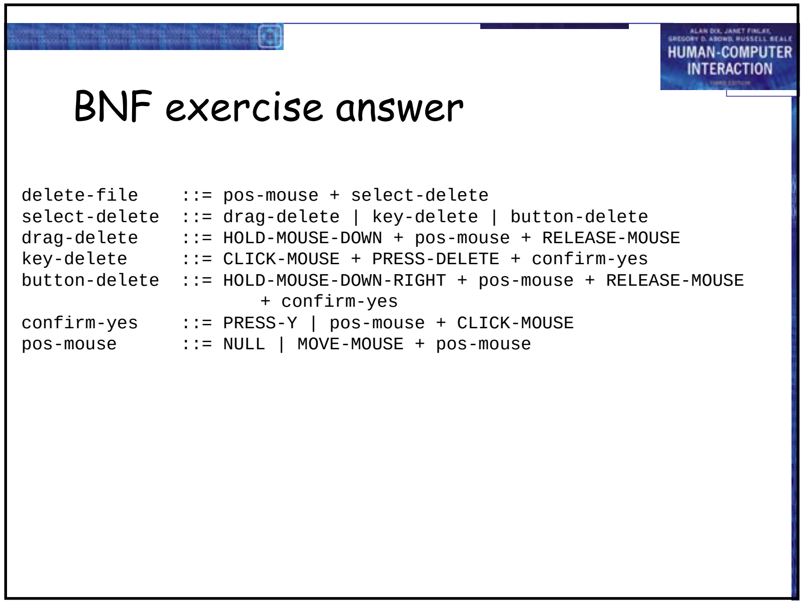
Backus-Naur Form (BNF)

- Very common notation from computer science
- A purely syntactic view of the dialogue
- Terminals
  - lowest level of user behaviour
  - e.g. CLICK-MOUSE, MOVE-MOUSE
- Nonterminals
  - ordering of terminals
  - higher level of abstraction
  - e.g. select-menu, position-mouse

Example of BNF

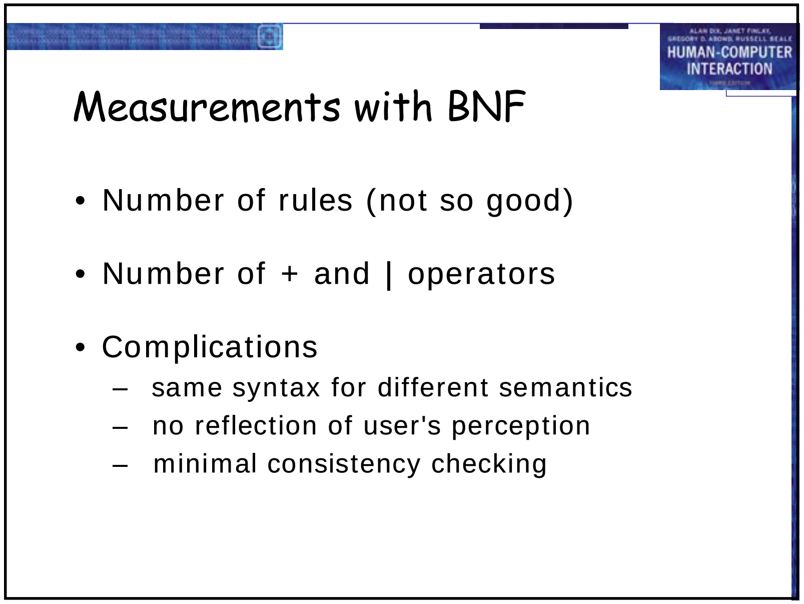
- Basic syntax:
  - nonterminal ::= expression
- An expression
  - contains terminals and nonterminals
  - combined in sequence (+) or as alternatives (|)

```
draw-line     ::=  select-line + choose-points + last-point
select-line   ::=  pos-mouse + CLICK-MOUSE
choose-points ::=  choose-one  |  choose-one + choose-points
choose-one    ::=  pos-mouse + CLICK-MOUSE
last-point    ::=  pos-mouse + DBL-CLICK-MOUSE
pos-mouse     ::=  NULL  |  MOVE-MOUSE + pos-mouse
```



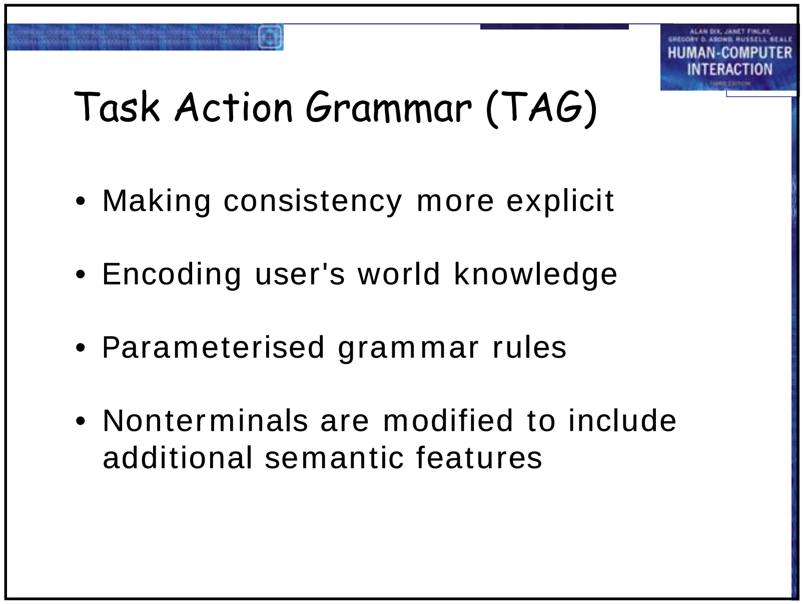
BNF exercise answer

```
delete-file    ::= pos-mouse + select-delete
select-delete  ::= drag-delete | key-delete | button-delete
drag-delete    ::= HOLD-MOUSE-DOWN + pos-mouse + RELEASE-MOUSE
key-delete     ::= CLICK-MOUSE + PRESS-DELETE + confirm-yes
button-delete  ::= HOLD-MOUSE-DOWN-RIGHT + pos-mouse + RELEASE-MOUSE
                       + confirm-yes
confirm-yes    ::= PRESS-Y | pos-mouse + CLICK-MOUSE
pos-mouse      ::= NULL | MOVE-MOUSE + pos-mouse
```



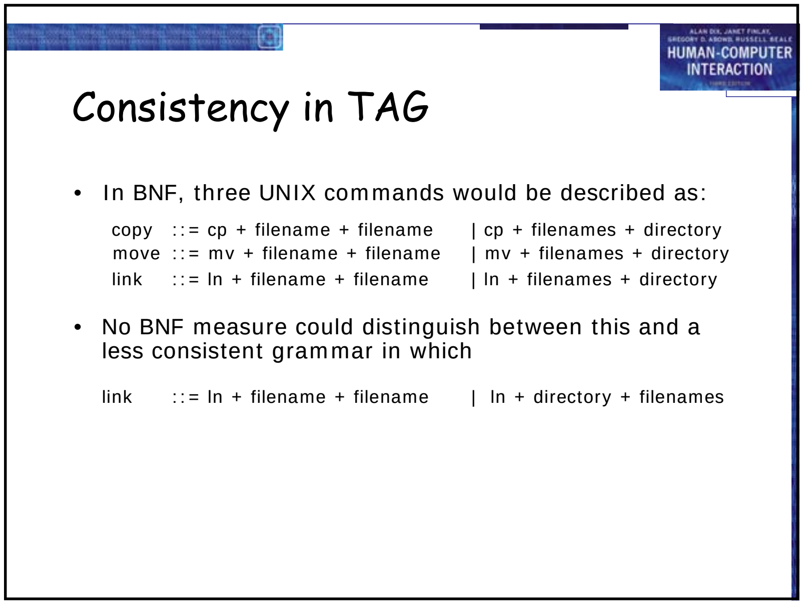
Measurements with BNF

- Number of rules (not so good)
- Number of + and | operators
- Complications
  - same syntax for different semantics
  - no reflection of user's perception
  - minimal consistency checking



Task Action Grammar (TAG)

- Making consistency more explicit
- Encoding user's world knowledge
- Parameterised grammar rules
- Nonterminals are modified to include additional semantic features



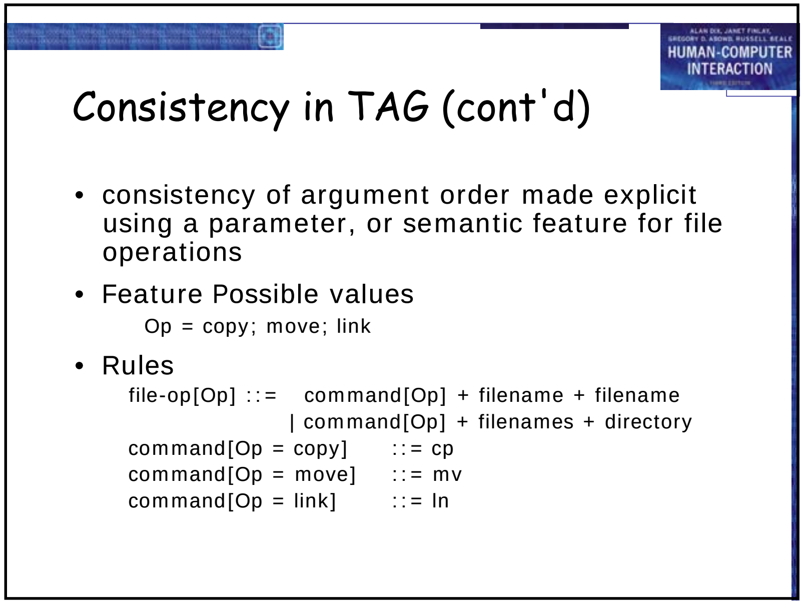
Consistency in TAG

- In BNF, three UNIX commands would be described as:

```
copy   ::= cp + filename + filename    | cp + filenames + directory
move   ::= mv + filename + filename    | mv + filenames + directory
link   ::= ln + filename + filename    | ln + filenames + directory
```

- No BNF measure could distinguish between this and a less consistent grammar in which

```
link   ::= ln + filename + filename    | ln + directory + filenames
```

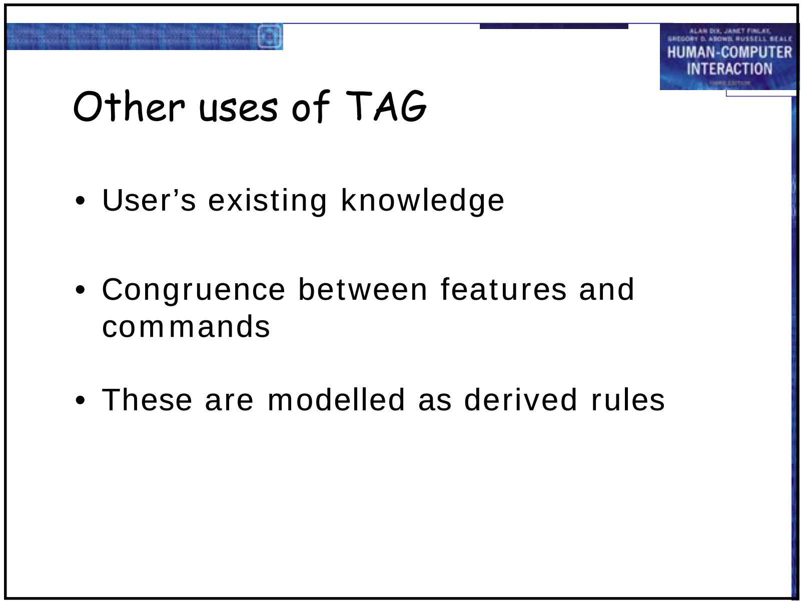


Consistency in TAG (cont'd)

- consistency of argument order made explicit using a parameter, or semantic feature for file operations
- Feature Possible values

  Op = copy; move; link
- Rules

```
file-op[Op] ::=   command[Op] + filename + filename
                | command[Op] + filenames + directory
command[Op = copy]     ::= cp
command[Op = move]     ::= mv
command[Op = link]     ::= ln
```



Other uses of TAG

- User’s existing knowledge
- Congruence between features and commands
- These are modelled as derived rules