ACT-R Software Updates August-December 2008

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Overview

- Notable changes since the Summer release (r617)
  - – Fall release in October r696
  - – Current (Winter) release is r723
- All updates are available
  - – Text log

    http://act-r.psy.cmu.edu/~webcron/actr6log.txt
  - – RSS feed

    http://act-r.psy.cmu.edu/~webcron/actr6feed.xml

Outline

- Changes available in the Fall release [r696]
- Changes available in the Winter release [r723]

Fall Release Highlights

- **Environment tools**
- Updates to existing modules
- New module
- Performance
- Miscellaneous

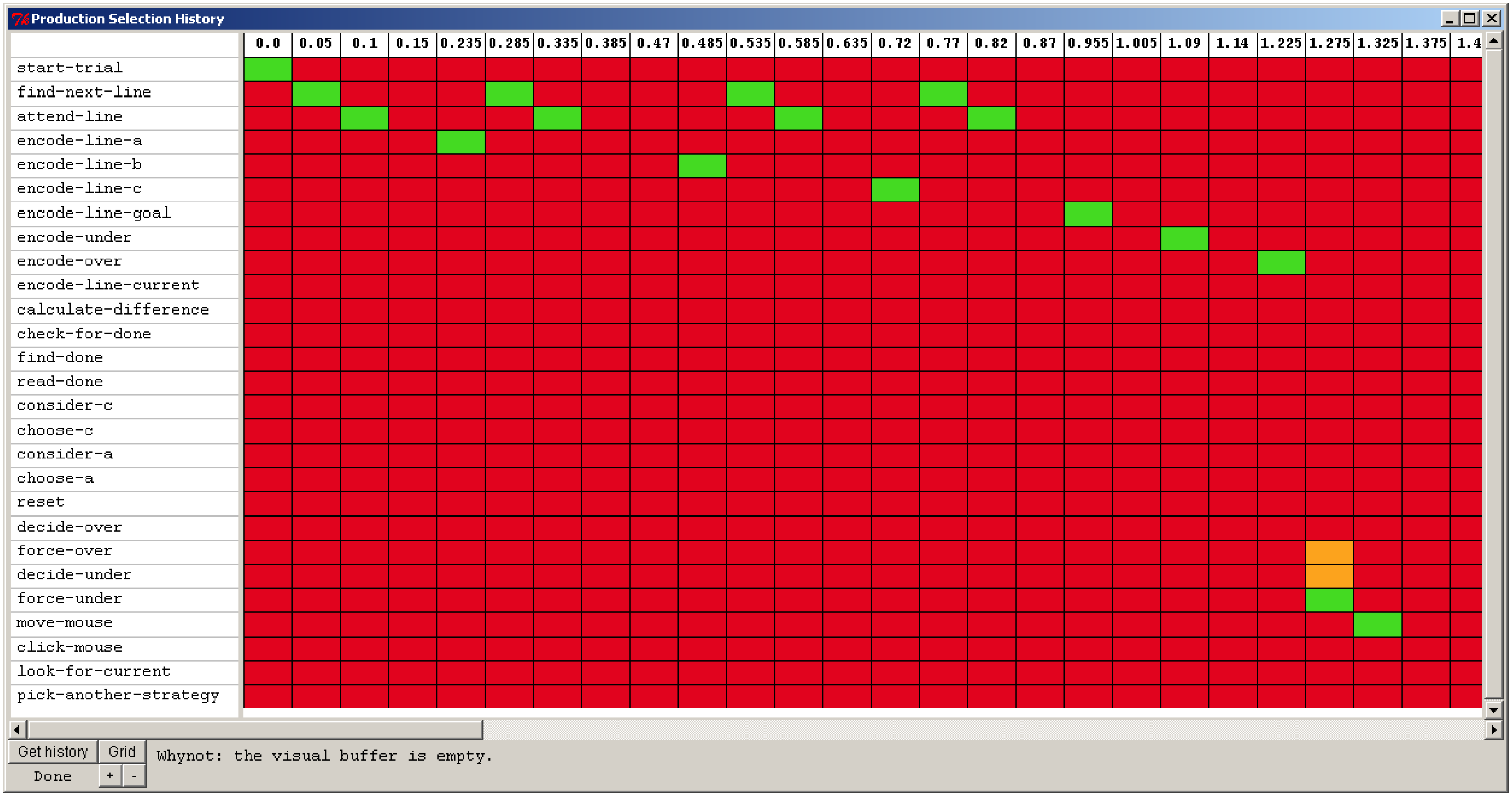
Environment Changes

- Graphic trace tools no longer require setting the :save-buffer-trace parameter to t
  - Just have to open the window prior to the model run, but after any reset
  - Setting the parameter still works and is safe across resets
- Chunks and productions in the graphic traces can be clicked on to open the declarative and procedural viewers with the item selected

Environment Additions

- Graphic run histories
  - Productions
  - Retrievals
  - Buffers
- Not available by default
  - In extras/history-tools
  - Move the files as indicated in the readme.txt

Production history

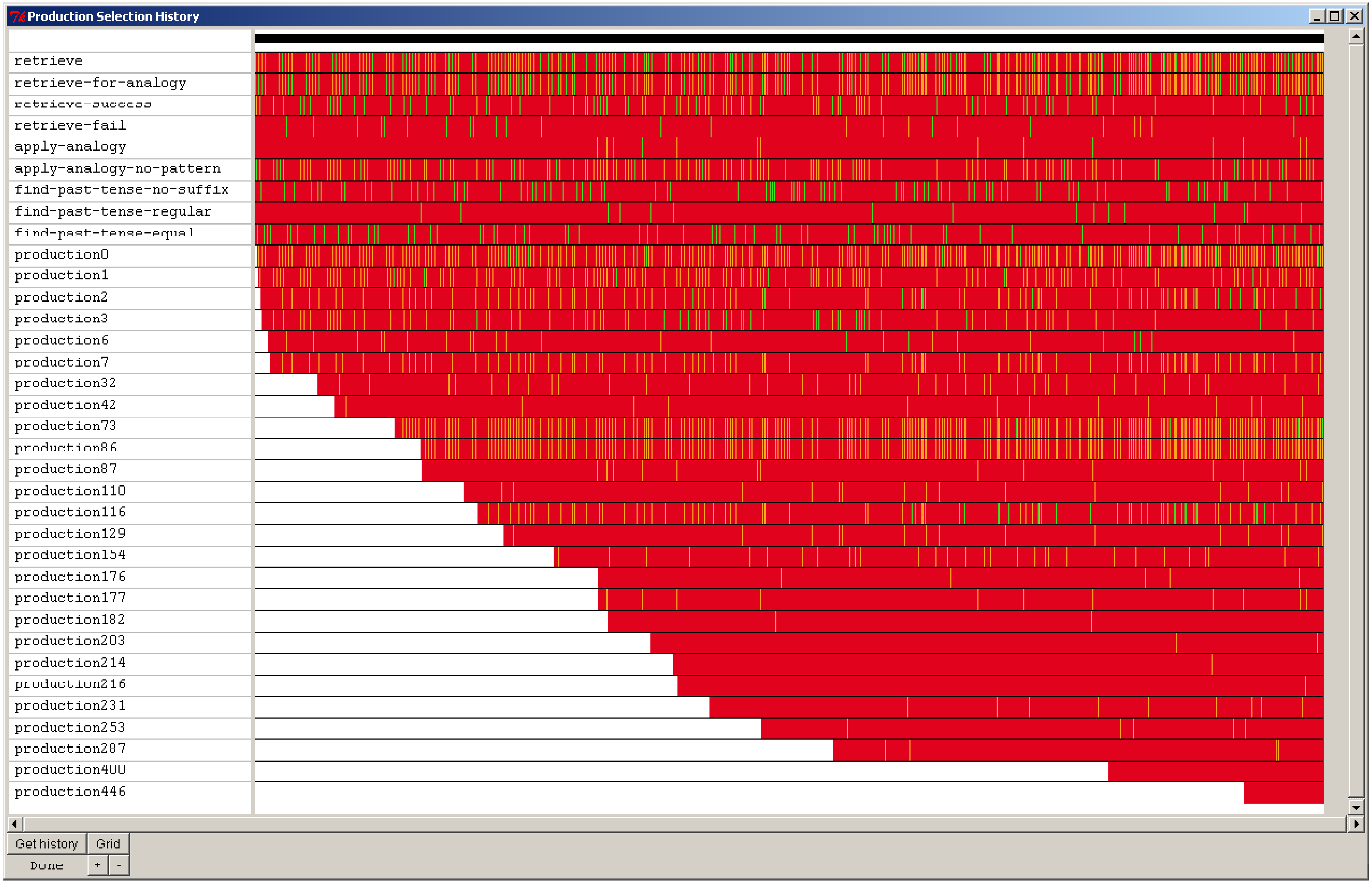


	0.0	0.05	0.1	0.15	0.235	0.285	0.335	0.385	0.47	0.485	0.535	0.585	0.635	0.72	0.77	0.82	0.87	0.955	1.005	1.09	1.14	1.225	1.275	1.325	1.375	1.4
start-trial	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
find-next-line	🟥	🟩	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
attend-line	🟥	🟥	🟩	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
encode-line-a	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
encode-line-b	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
encode-line-c	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
encode-line-goal	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
encode-under	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟥
encode-over	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥
encode-line-current	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
calculate-difference	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
check-for-done	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
find-done	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
read-done	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
consider-c	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
choose-c	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
consider-a	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
choose-a	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
reset	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
decide-over	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
force-over	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟧	🟥	🟥	🟥
decide-under	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟧	🟥	🟥	🟥
force-under	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥
move-mouse	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥
click-mouse	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
look-for-current	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
pick-another-strategy	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥

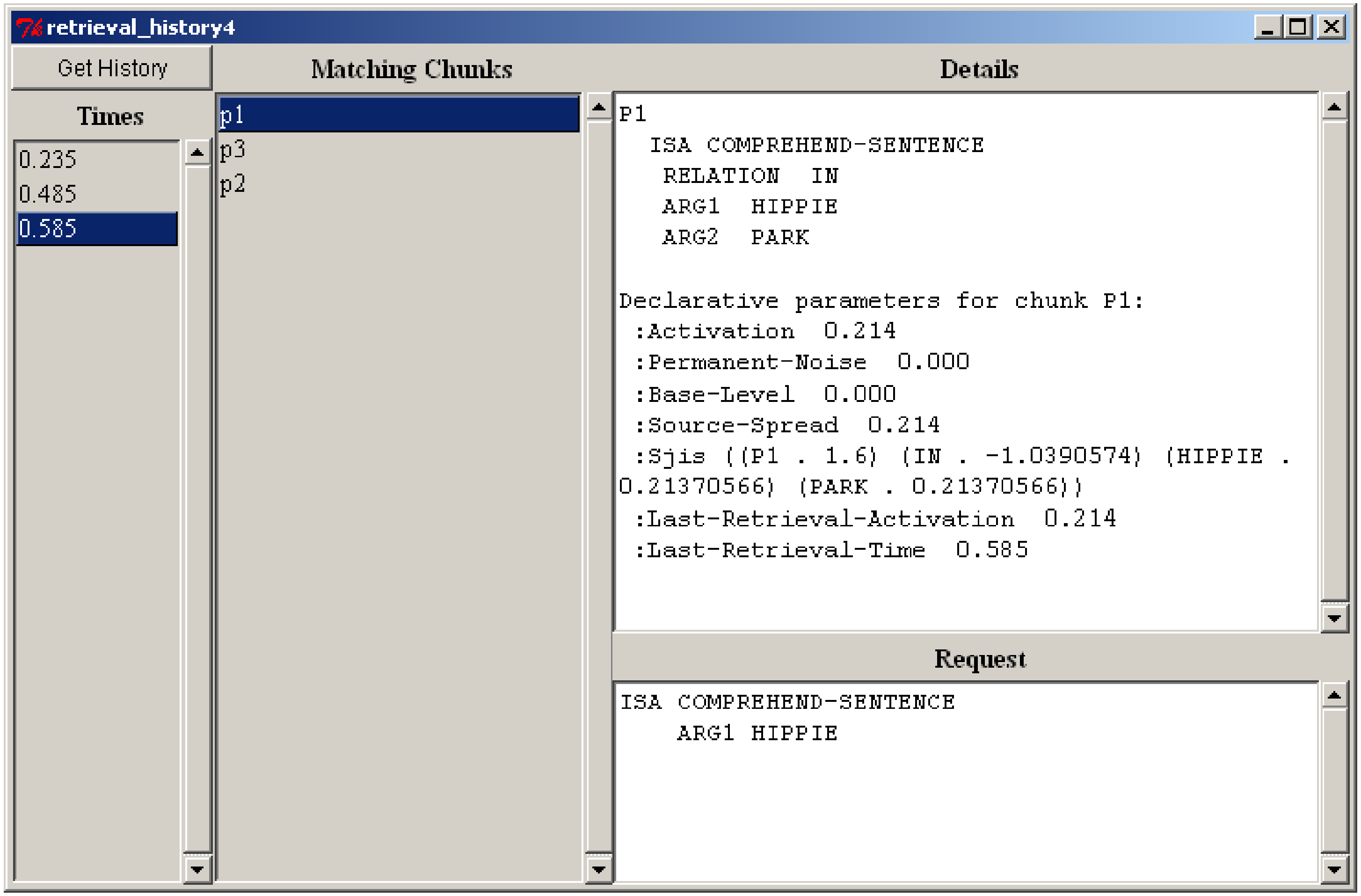
```
Whynot: the visual buffer is empty.
```

Production history (cont)

- One row per production
- Column for every conflict-resolution labeled with the time it occurred
- Color indicates if the production was in the conflict set
  - Green chosen production
  - Orange in the set and not chosen
  - Red not in the set
- Putting the cursor over a block shows
  - Utility for productions in the set
  - Whynot info for those not in the set


Production Selection History
retrieve
retrieve-for-analogy
retrieve-success
retrieve-fail
apply-analogy
apply-analogy-no-pattern
find-past-tense-no-suffix
find-past-tense-regular
find-past-tense-equal
production0
production1
production2
production3
production6
production7
production32
production42
production73
production86
production87
production110
production116
production129
production154
production176
production177
production182
production203
production214
production216
production231
production253
production287
production400
production446
Get history
Grid
Done
+
-

Retrieval history



```
0.235
0.485
0.585
```

```
p1
p3
p2
```

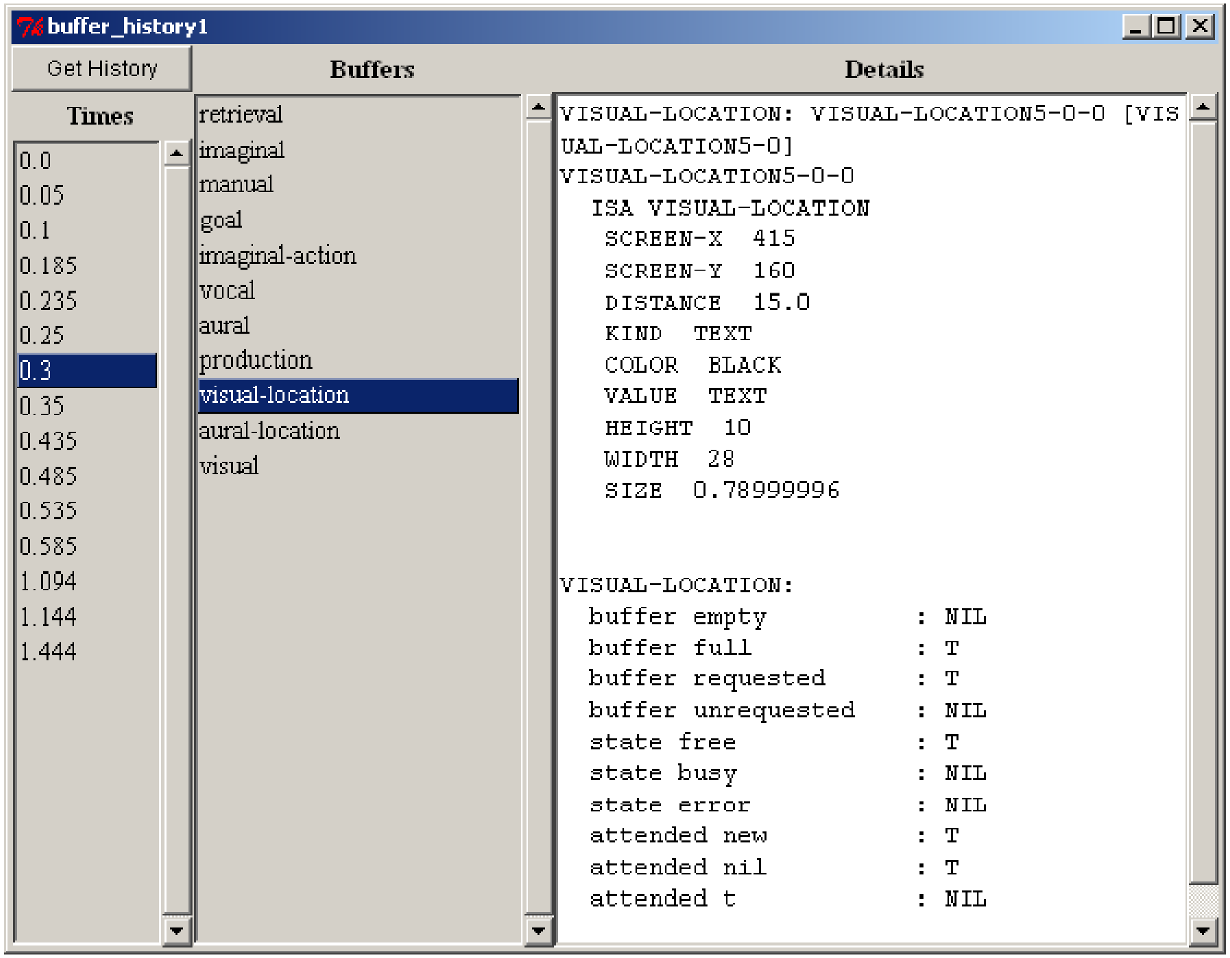
```
P1
  ISA COMPREHEND-SENTENCE
   RELATION  IN
   ARG1  HIPPIE
   ARG2  PARK

Declarative parameters for chunk P1:
 :Activation  0.214
 :Permanent-Noise  0.000
 :Base-Level  0.000
 :Source-Spread  0.214
 :Sjis ((P1 . 1.6) (IN . -1.0390574) (HIPPIE .
0.21370566) (PARK . 0.21370566))
 :Last-Retrieval-Activation  0.214
 :Last-Retrieval-Time  0.585
```

```
ISA COMPREHEND-SENTENCE
    ARG1 HIPPIE
```

Retrieval history (cont)

- Left column is times when a retrieval request occurred
- Right column is all chunks which matched the request at the time selected in the left column
- Windows on the right show details
  - Top window
    - The chunk selected in the middle column with parameters at the time of the request
  - Bottom window
    - The retrieval request which was made

Buffer history



```
VISUAL-LOCATION: VISUAL-LOCATION5-0-0 [VIS
UAL-LOCATION5-0]
VISUAL-LOCATION5-0-0
  ISA VISUAL-LOCATION
   SCREEN-X  415
   SCREEN-Y  160
   DISTANCE  15.0
   KIND  TEXT
   COLOR  BLACK
   VALUE  TEXT
   HEIGHT  10
   WIDTH  28
   SIZE  0.78999996


VISUAL-LOCATION:
  buffer empty          : NIL
  buffer full           : T
  buffer requested      : T
  buffer unrequested    : NIL
  state free            : T
  state busy            : NIL
  state error           : NIL
  attended new          : T
  attended nil          : T
  attended t            : NIL
```

Buffer history (cont)

- Left column shows all the times when some scheduled buffer change occurred
- Right column shows all the buffer names
- Window on the right shows details of the selected buffer at the selected time
  - Chunk in the buffer at that time
  - Buffer status information at that time

Fall Release Highlights

- Environment tools
- **Updates to existing modules**
- New module
- Performance
- Miscellaneous

Declarative module

- New parameter :w-hook
  - Allows one to adjust the W_{kj} values in the spreading activation equation
  - Set to a function like other hooks
  - Passed two parameters:
    - buffer name and slot name
  - If it returns a number that overrides the default W_{kj} value

Vision Module

- New queries for visual buffer
  - Scene-change
  - Scene-change-value
- Alternate mechanism for detecting screen changes
  - More reliable than visual-location buffer stuffing
  - Has a settable change threshold
    - :scene-change-threshold

Scene-change

- The query:

  ?visual>

    scene-change t

  will be true when all of these are true

  – there has been a proc-display call within :visual-onset-span seconds

  – The change in the visicon at that time was at or above the threshold (.25 default value)

  – The notice has not been explicitly cleared

Scene-change (cont)

- Change is defined as:

$$Change = \frac{d+n}{o+n}$$

o: The number of features in the visicon prior to the update

d : The number of features which have been deleted from the original visicon

n: The number of features which are newly added to the visicon by the update

- Can be explicitly cleared with a clear-scene-change request or the existing clear request

  +visual> isa clear-scene-change

  +visual> isa clear

Scene-change-value

- Primarily for buffer-status use:

```
VISUAL:
...
scene-change          : T
scene-change-value    : 1.0
```

- Shows the last change value
- Can be queried with a number:

  ?visual>

  Scene-change-value x

- Will be true if last scene-change-value >= x

Fall Release Highlights

- Environment tools
- Updates to existing modules
- **New module**
- Performance
- Miscellaneous

Blending module

- New module to perform blended retrievals
- Not installed by default
  - In extras/blending
  - See the blending-read-me.txt for installation info and module details
- Also Included
  - Christian’s slides describing the original mechanism in detail
  - Some example models using the module

Blending module overview

- Assumes the default declarative module exists
- Has one buffer called blending
- Takes requests like the retrieval buffer does
  - Results in a chunk being placed into the blending buffer if successful
- Responds to queries for state busy, free and error the same way the retrieval buffer does
  - State is independent of the declarative module's

Blending request basics

- Create a resulting chunk with
  - The chunk-type of the requested chunk
  - All the explicit values given in the request
  - Blended slot values for all other slots

Blending request details

- Start with the set of chunks which match the request
- Compute the activation, A_i, of each chunk in that set using the normal declarative mechanisms
- Use those activations and the temperature setting of the blending module (:tmp) to compute the probability of each chunk in the set being retrieved using the Boltzmann equation
- Now we have a p_i value for each chunk i in the matching set

Blending request details (cont)

- For each blended slot
- Consider the values in the corresponding slots of every chunk i in the matching set
  - Call that v_i
- Three cases
  - All v_i are numbers
  - All v_i are chunks
  - Something else
    - Not going to cover this case

All v_i are numbers

- The value for the slot is:

$$\sum_i p_i * v_i$$

All v_i are chunks

- Consider all chunks of that chunk-type as potential values (or all chunks if there is no common chunk-type among the v_i chunks)
- For each potential value j compute:

$$B_j = \sum_i p_i * sim(i,j)^2$$

- The value for the slot is the chunk j with the minimum B_j value

Blending time and success

- Compute a match score for the blended chunk

$$M = \log \sum_i e^{A_i}$$

- If M >= the retrieval threshold the chunk is placed in the blending buffer after a time

$$BT = Fe^{-(f*M)}$$

- Other wise it fails after a time based on the retrieval threshold

Blending Example (matching set, A_i and p_i)

blending-test-1.lisp:

```
(sgp :v t :blt t :esc t :ans .25 :rt 4)
(chunk-type target key value size)
(chunk-type size)
(add-dm
   (tiny isa size) (small isa size) (medium isa size)
   (large isa size)(x-large isa size)

   (a isa target key key-1 value 1 size large)
   (b isa target key key-1 value 2 size x-large)
   (c isa target key key-1 value 3 size tiny)
   (d isa target key key-2 value 1 size nil)
   (e isa target key key-2 value 3 size small))

(set-similarities (tiny small -.1) (small medium -.1)
   (medium large -.1)(large x-large -.1)(tiny medium -.3)
   (small large -.3)(medium x-large -.3)(tiny large -.6)
   (small x-large -.6)(tiny x-large -.9))

  (p p1 ... ==>
     +blending>
       isa target
       key key-1)
```

```
0.050   BLENDING             START-BLENDING
Blending request for chunks of type TARGET
Blending temperature defaults to (* (sqrt 2) :ans): 0.35355338
Chunk C matches blending request
  Activation 3.5325232
  Probability of recall 0.2851124

Chunk B matches blending request
  Activation 3.763482
  Probability of recall 0.5479227

Chunk A matches blending request
  Activation 3.3433368
  Probability of recall 0.16696489

Slots to be blended: (VALUE SIZE)
```

Blending Example (computing value slot)

blending-test-1.lisp:

```
(sgp :v t :blt t :esc t :ans .25 :rt 4)
(chunk-type target key value size)
(chunk-type size)
(add-dm
  (tiny isa size) (small isa size) (medium isa size)
  (large isa size)(x-large isa size)

  (a isa target key key-1 value 1 size large)
  (b isa target key key-1 value 2 size x-large)
  (c isa target key key-1 value 3 size tiny)
  (d isa target key key-2 value 1 size nil)
  (e isa target key key-2 value 3 size small))

(set-similarities (tiny small -.1) (small medium -.1)
  (medium large -.1)(large x-large -.1)(tiny medium -.3)
  (small large -.3)(medium x-large -.3)(tiny large -.6)
  (small x-large -.6)(tiny x-large -.9))

 (p p1 ... ==>
   +blending>
     isa target
     key key-1)
```

```
Finding blended value for slot: VALUE
Matched chunks' slots contain: (3 2 1)
Magnitude values for those items: (3 2 1)
With numeric magnitudes blending by weighted average
 Chunk C with probability 0.2851124 times magnitude 3.0 cumulative result: 0.85533726
 Chunk B with probability 0.5479227 times magnitude 2.0 cumulative result: 1.9511826
 Chunk A with probability 0.16696489 times magnitude 1.0 cumulative result: 2.1181474
 Final result: 2.1181474
```

Blending Example (Computing size slot)

blending-test-1.lisp:

```
(sgp :v t :blt t :esc t :ans .25 :rt 4)
(chunk-type target key value size)
(chunk-type size)
(add-dm
  (tiny isa size) (small isa size) (medium isa size)
  (large isa size)(x-large isa size)

  (a isa target key key-1 value 1 size large)
  (b isa target key key-1 value 2 size x-large)
  (c isa target key key-1 value 3 size tiny)
  (d isa target key key-2 value 1 size nil)
  (e isa target key key-2 value 3 size small))

(set-similarities (tiny small -.1) (small medium -.1)
  (medium large -.1)(large x-large -.1)(tiny medium -.3)
  (small large -.3)(medium x-large -.3)(tiny large -.6)
  (small x-large -.6)(tiny x-large -.9))

 (p p1 ... ==>
   +blending>
     isa target
     key key-1)
```

```
Finding blended value for slot: SIZE
Matched chunks' slots contain: (TINY X-LARGE LARGE)
Magnitude values for those items: (TINY X-LARGE LARGE)
When all magnitudes are chunks or nil blending based on common chunk-types and
      similarities
Common chunk-type for values is: SIZE
 Comparing value TINY
  Chunk C with probability 0.285 slot value TINY similarity: 0.0 cumulative result: 0.0
  Chunk B with probability 0.547 slot value X-LARGE similarity: -0.9 cumulative result: 0.443
  Chunk A with probability 0.166 slot value LARGE similarity: -0.6 cumulative result: 0.503
 Comparing value SMALL
  Chunk C with probability 0.285 slot value TINY similarity: -0.1 cumulative result: 0.002
  Chunk B with probability 0.547 slot value X-LARGE similarity: -0.6 cumulative result: 0.200
  Chunk A with probability 0.166 slot value LARGE similarity: -0.3 cumulative result: 0.215
 Comparing value MEDIUM
  Chunk C with probability 0.285 slot value TINY similarity: -0.3 cumulative result: 0.0256
  Chunk B with probability 0.547 slot value X-LARGE similarity: -0.3 cumulative result: 0.074
  Chunk A with probability 0.166 slot value LARGE similarity: -0.1 cumulative result: 0.076
 Comparing value LARGE
  Chunk C with probability 0.285 slot value TINY similarity: -0.6 cumulative result: 0.102
  Chunk B with probability 0.547 slot value X-LARGE similarity: -0.1 cumulative result: 0.108
  Chunk A with probability 0.166 slot value LARGE similarity: 0.0 cumulative result: 0.108
 Comparing value X-LARGE
  Chunk C with probability 0.285 slot value TINY similarity: -0.9 cumulative result: 0.230
  Chunk B with probability 0.547 slot value X-LARGE similarity: 0.0 cumulative result: 0.230
  Chunk A with probability 0.166 slot value LARGE similarity: -0.1 cumulative result: 0.232
 Final result: MEDIUM
```

Blending Example (time and success)

blending-test-1.lisp:

```
(sgp :v t :blt t :esc t :ans .25 :rt 4)
(chunk-type target key value size)
(chunk-type size)
(add-dm
   (tiny isa size) (small isa size) (medium isa size)
   (large isa size)(x-large isa size)

   (a isa target key key-1 value 1 size large)
   (b isa target key key-1 value 2 size x-large)
   (c isa target key key-1 value 3 size tiny)
   (d isa target key key-2 value 1 size nil)
   (e isa target key key-2 value 3 size small))

(set-similarities (tiny small -.1) (small medium -.1)
   (medium large -.1)(large x-large -.1)(tiny medium -.3)
   (small large -.3)(medium x-large -.3)(tiny large -.6)
   (small x-large -.6)(tiny x-large -.9))

  (p p1 ... ==>
    +blending>
      isa target
      key key-1)
```

```
This is the definition of the blended chunk:
(ISA TARGET KEY KEY-1 SIZE MEDIUM VALUE 2.1181474)

Computing activation and latency for the blended chunk
 Activation of chunk C is 3.5325232
 Activation of chunk B is 3.763482
 Activation of chunk A is 3.3433368
Activation for blended chunk is: 4.6598654
    0.050   PROCEDURAL          CONFLICT-RESOLUTION
    0.059   BLENDING            BLENDING-COMPLETE
```

Fall Release Highlights

- Environment tools
- Updates to existing modules
- New module
- **Performance**
- Miscellaneous

Performance

- Added a set of test models to measure long term performance values
  - Ensure things are at least linear
- Lots of little changes
  - Minor code changes (append -> nconc, etc)
  - Internal representations
    - Things people shouldn’t notice
- Two updates for the vision module

Vision module performance

- Since it uses chunks internally there're a lot of "garbage" chunks created
  - used once and then not needed
- The built-in GUI tools now reuse and delete their chunks when not needed
- New parameter :delete-visicon-chunks
  - The module's internal chunks also get deleted
  - Defaults to t
  - May need to set to nil to work with some extensions (EMMA)

Fall Release Highlights

- Environment tools
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Miscellaneous

- Manual now has sections on
  - Working with chunk-specs
  - Accessing and using buffers
  - Adding new chunk parameters
  - Defining new modules
- New command: capture-model-output
  - Works like no-output to suppress output except it stores it in a string which it returns
- Changes to some feature checks to work right with Clozure Common Lisp (was previously OpenMCL)

Updates for the Winter release

- Changed the internal mechanisms used to hold and compute the chunk fan values
- Added a third reset function option for modules
- New option for normalizing chunk names
- Ongoing performance improvement work
  - Still experimental
  - Available for testing if interested

New fan storage mechanism

- Previously
  - Saved the list of all i’s in the chunk j (j is the source i is the chunk with a connection to j)
  - Required searching that list when computing fan$_{ji}$ (fan-out$_{j}$/fan-in$_{ji}$)
- Now
  - Store only the total fan-out count in j
  - Store the fan-in count for each j in i
- Much faster for models with large fan-outs
- If you were accessing that fan-out list it’s not there now
  - Wasn’t available through the normal mechanisms anyway
  - Could add a flag to still save it if people really need that

Third reset function

- Modules now have an additional option for when they can get called during reset
  - After all the model code evaluated
- It’s set as a third item in the :reset list when defining the module if needed

“New” Chunk name Normalizing

- New parameter :dcnn (dynamic chunk name normalizing)
- Works in conjunction with :ncnar
- When both are true (the default values)
  - Chunk names are normalized as the model runs instead of at the end
  - When chunks merge all slots of ALL chunks which have the merged name are updated to the true name
  - Much closer to how the older ACT-Rs worked

More on :dcnn

- Primarily for model debugging
  - Never see multiple names for one chunk
  - Should not affect the operation of the model
- May or may not be faster that normalizing at the end
  - Depends on how much merging occurs, the interrelations among the chunks, and how many chunks the model has
- Does require extra storage to hold the back-links
  - So a larger memory footprint is required to use it
- For best performance :ncnar should still be set to nil
  - Disables all the normalizing

Simple :dcnn example

```
(chunk-type goal slot)

(add-dm (name isa chunk))

(p start
   ?goal>  buffer empty
  ==>
   +goal> isa goal
   +retrieval> isa chunk)

(p set-up
   =goal> isa goal
   =retrieval> isa chunk
  ==>
   =goal>
    slot =retrieval)

(p report
   =goal>
    isa goal
    slot =value
  ==>
   !output! (the value is =value)
   !stop!))
```

```
CG-USER(12): (sgp :dcnn nil)
(NIL)
CG-USER(13): (run 10)
     0.050   PROCEDURAL   PRODUCTION-FIRED START
     0.050   GOAL         SET-BUFFER-CHUNK GOAL GOAL0
     0.050   DECLARATIVE  SET-BUFFER-CHUNK RETRIEVAL NAME
     0.100   PROCEDURAL   PRODUCTION-FIRED SET-UP
     0.150   PROCEDURAL   PRODUCTION-FIRED REPORT
THE VALUE IS NAME-0
     0.150   ------       BREAK-EVENT Stopped by !stop!

CG-USER(9): (sgp :dcnn t)
(T)
CG-USER(10): (run 10)
     0.050   PROCEDURAL   PRODUCTION-FIRED START
     0.050   GOAL         SET-BUFFER-CHUNK GOAL GOAL0
     0.050   DECLARATIVE  SET-BUFFER-CHUNK RETRIEVAL NAME
     0.100   PROCEDURAL   PRODUCTION-FIRED SET-UP
     0.150   PROCEDURAL   PRODUCTION-FIRED REPORT
THE VALUE IS NAME
     0.150   ------       BREAK-EVENT Stopped by !stop!
```

Ongoing Update Work

- Improve performance
  - Development focus has been primarily on functionality up to this point
  - Try to stay ahead of demand
- Identify a mechanism that
  - Takes a significant amount of time
  - Common to most/all models
  - Shows an opportunity for improvement without significantly affecting current users

The conflict-resolution event

- Common to just about every model
- Profiling a variety of models showed that it typically accounts for somewhere between 20-50% of the run time
  - Primarily in the production matching code
    - Not the actual “conflict resolution” calculation
- Matching is a completely internal mechanism
  - No user hooks or access to the low-level operation

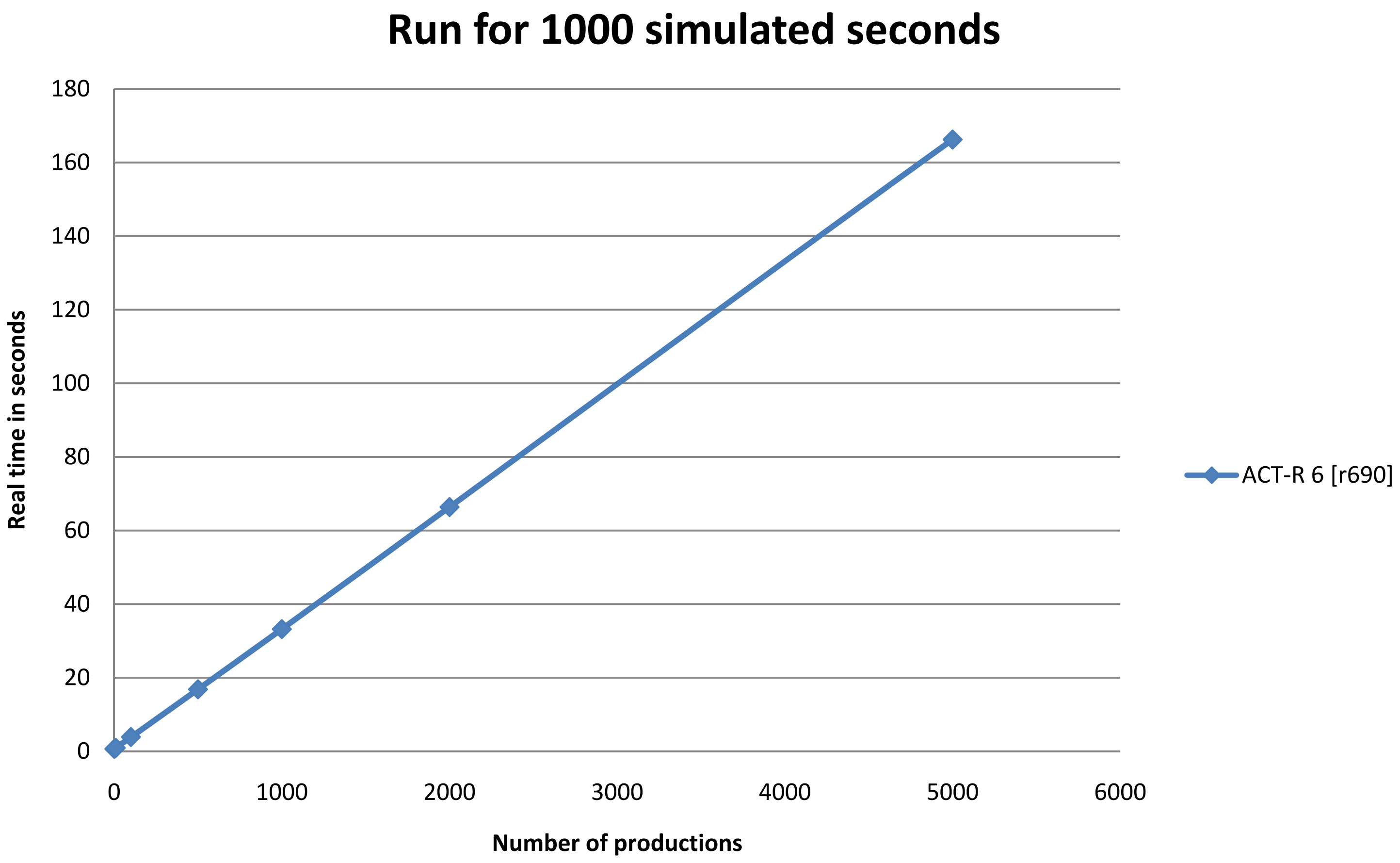
Current Algorithm

- For each production

  Test each condition until

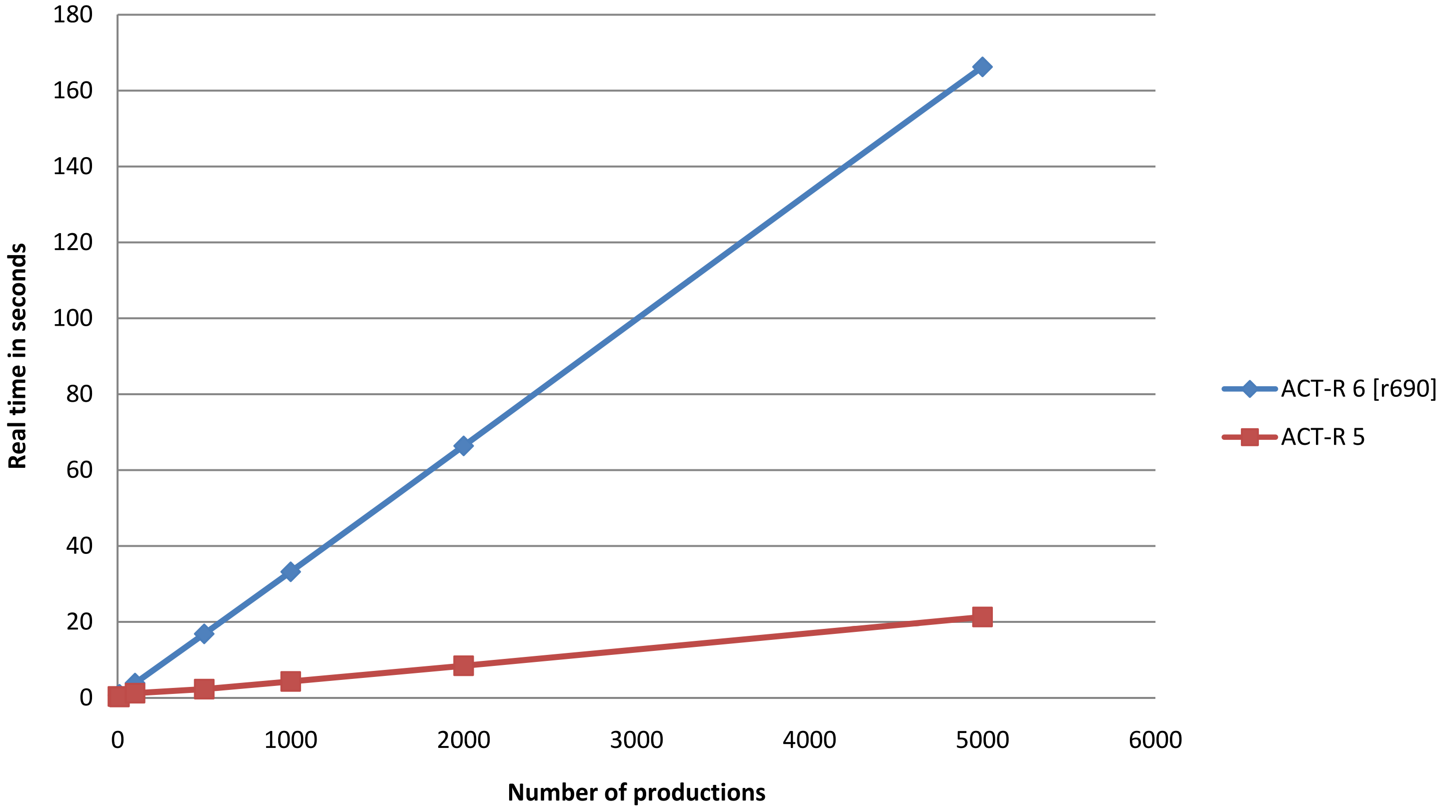
    all successful or one fails

  - Same as previous versions*
- Linear in the total number of conditions in the productions
  - Because each condition is a simple test – no search
- Checked with a simple performance testing model
  - Each production has two conditions and no actions
  - One production matches and n do not match
    - (p target =goal> isa test slot target ==>)
    - (p fail***n*** =goal> isa test slot fail***n*** ==>)
  - No other events in the model
  - Essentially the only thing happening is conflict-resolution events


Run for 1000 simulated seconds
Real time in seconds
180
160
140
120
100
80
60
40
20
0
0
1000
2000
3000
4000
5000
6000
Number of productions
ACT-R 6 [r690]

- Linear – good
- Doesn’t seem too bad
- Compare to similar model in ACT-R 5.0

Run for 1000 simulated seconds



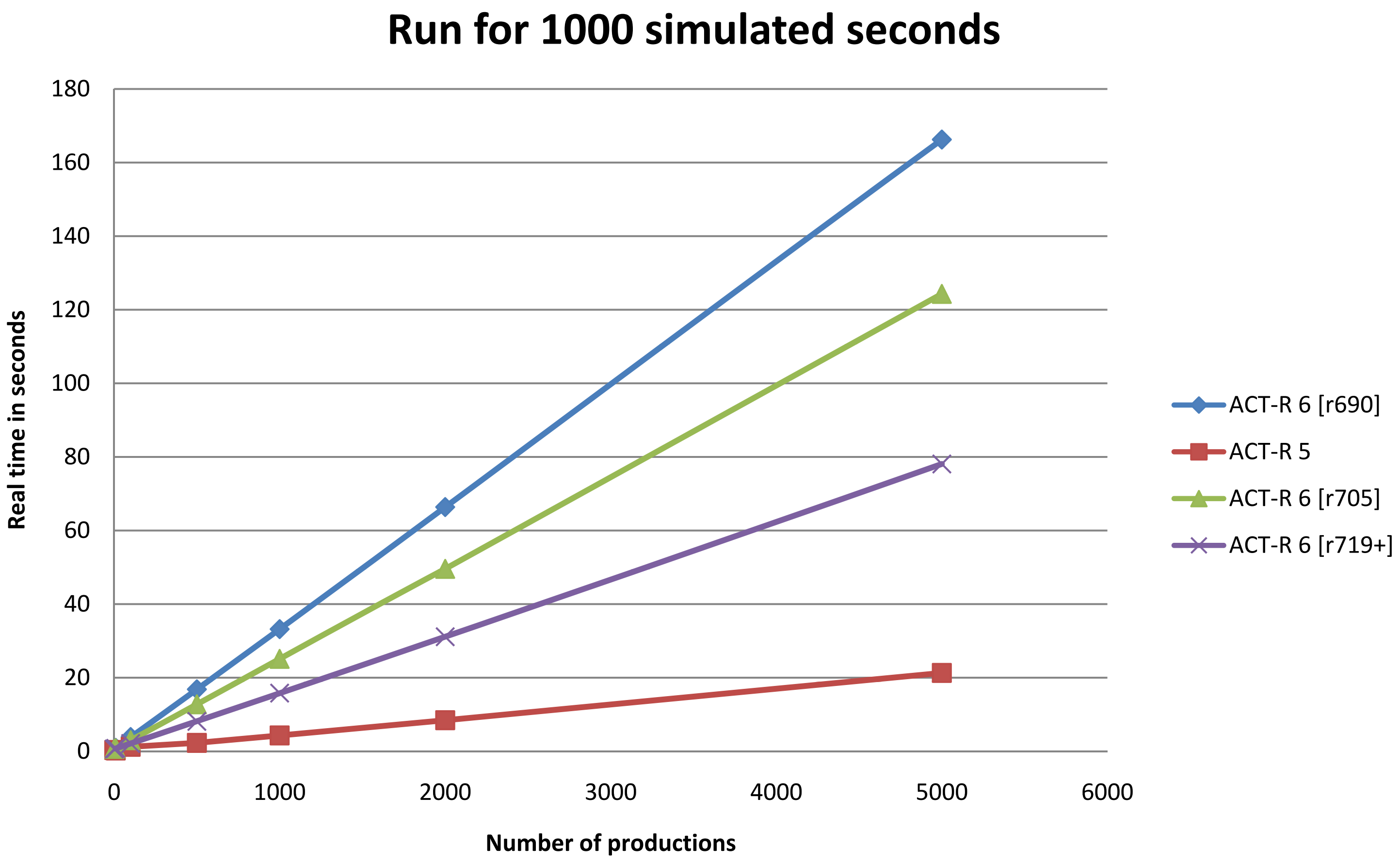
- Room for improvement
- Not unexpected
  - Christian did a lot of work to improve ACT-R 4.0
  - ACT-R 6.0 has had little performance work
  - More abstraction in 6.0
    - Probably never get to performance of 4.0/5.0 using the same algorithm

Plan forward

- Two strategies
  - Improve the internal production representation and code
  - Change the algorithm
- Working on both basically in parallel

Code changes

- Two big updates so far
- Replaced the use of the general chunk matching commands with specific code for buffer chunks which cache the results
- Replaced the lambdas that were generated at parse time with a structured representation that's tested at run time instead of evaled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ACT-R 6 [r690]
ACT-R 5
ACT-R 6 [r705]
ACT-R 6 [r719+]

Algorithm

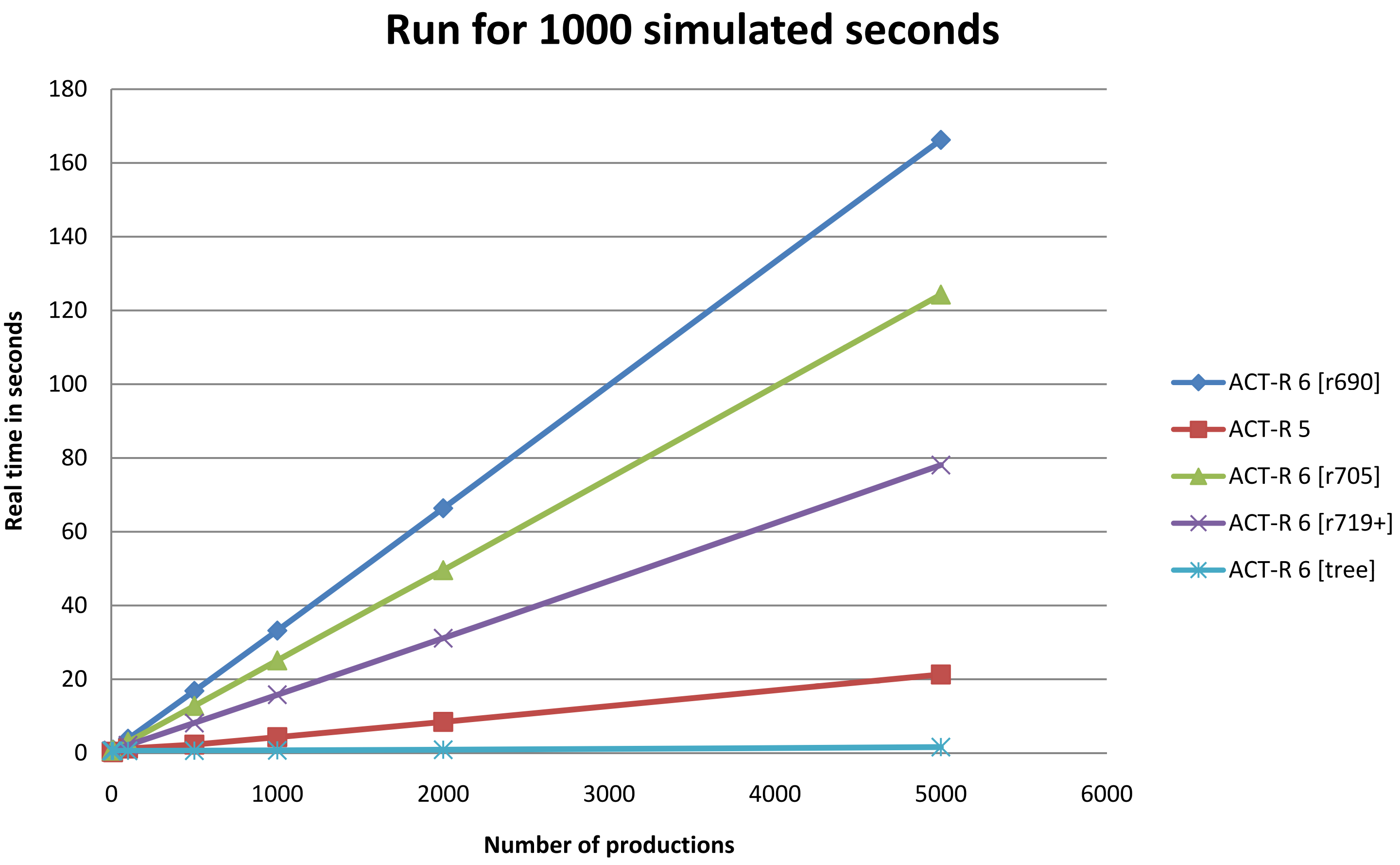
- Better than linear across all conditions?
- Why not use RETE?
  - Doesn’t really fit our situation
    - We don’t require search in matching
      - Already linear in number of conditions
    - We have a fairly small set of items to match (buffer slots)
- Try just a simple decision tree

Decision tree

- Only considering the constant tests in the productions at this point
  - Isa tests, specific slot values, and queries
- Nodes represent the conditions
  - Branches for the possible values
- Leaves are a set of productions which may need further testing
- At matching time it just needs to walk a path from the root to a leaf

Current implementation

- Creates the tree given all the productions
  - That's why the third reset hook was added
- Use an existing algorithm to build it – ID3
  - Add the condition which has the most information gain
  - Heuristic favors smaller depth trees
- Stop a branch when there're no more common conditions to test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ACT-R 6 [r690]
ACT-R 5
ACT-R 6 [r705]
ACT-R 6 [r719+]
ACT-R 6 [tree]

Needs more testing

- That test model is essentially the best possible situation for the tree
- Run times with other models did improve
- Not without potential issues
  - Time to build the tree
  - Space to hold the tree
- Not enabled by default
  - need to set the :use-tree parameter to t
  - Should work for all models including those using production compilation