Parallel Computing in R using NetWorkSpaces

N Carriero, J Lai, M Schultz, S Weston
and G Warnes

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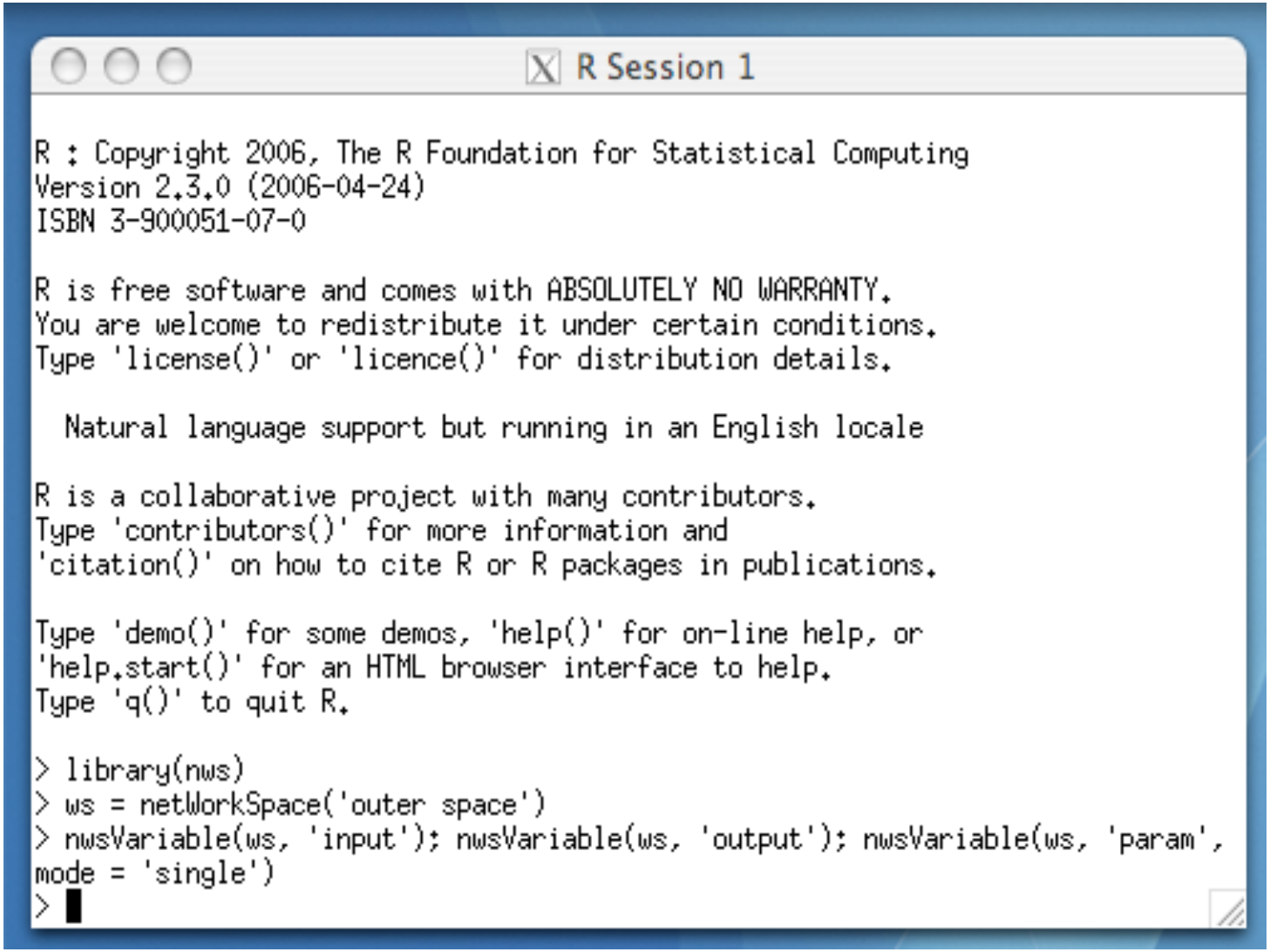
Yale Center for High Performance Computation in Biology and Biomedicine and NIH grant: RR19895-02

Scientific Computing Associates, Inc.

Pfizer

Shared Workspaces

- Variation on the theme of a workspace.
- The NetWorkSpace object encapsulation uses an Internet-based server to hold the workspace.
- A given NetWorkSpace can be accessed by multiple processes: *Any process capable of instantiating an appropriate NetWorkSpace object may retrieve the value of a variable.* (Or store (name, value) pairs for that matter.)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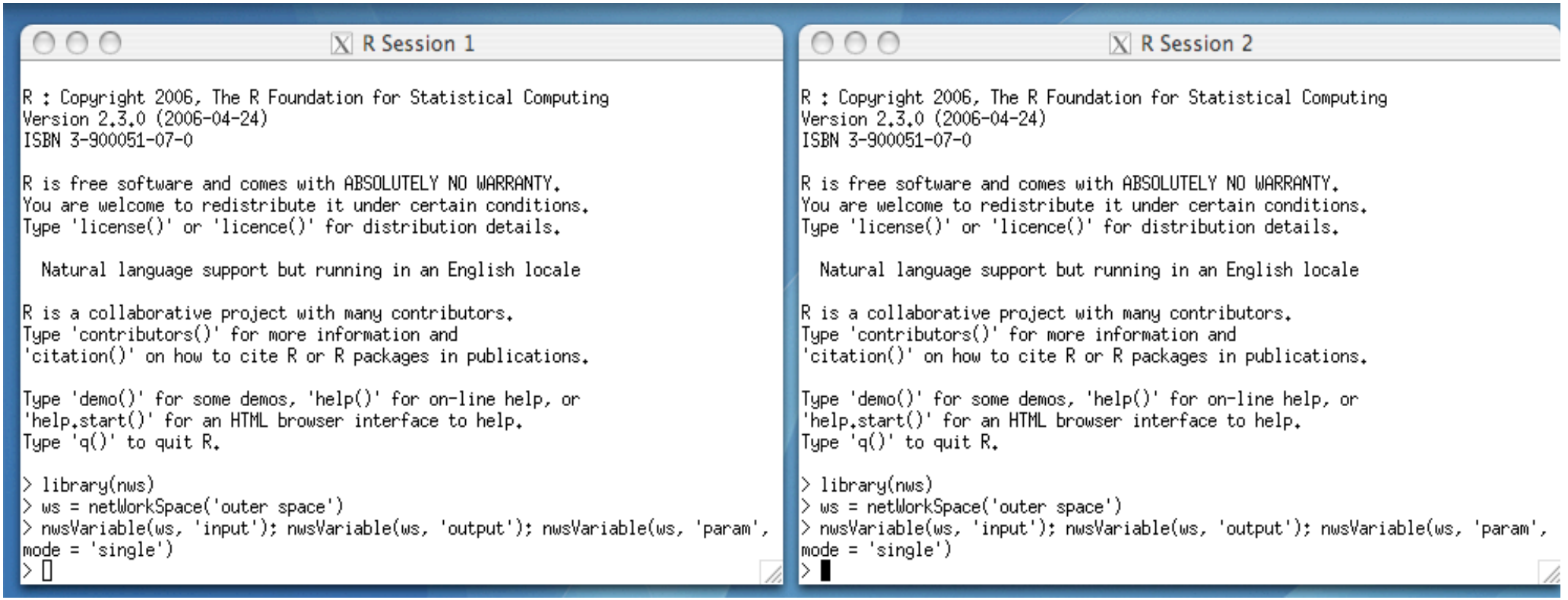
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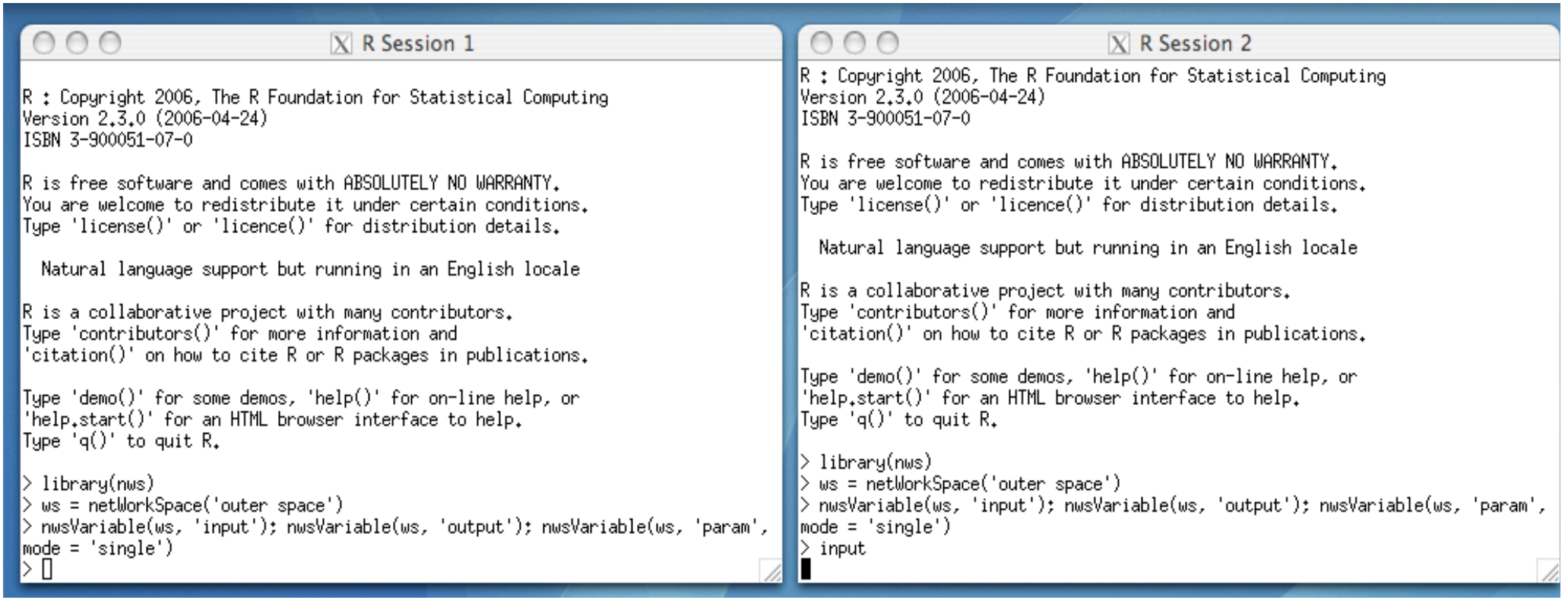
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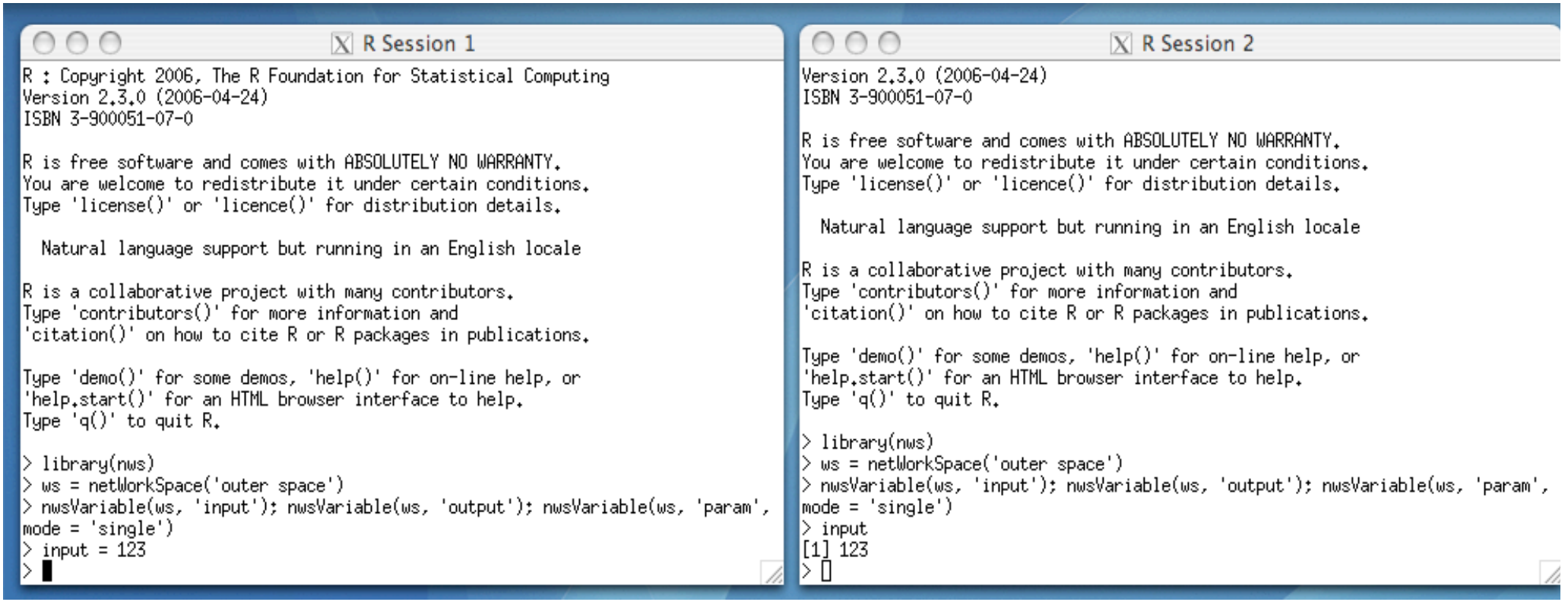
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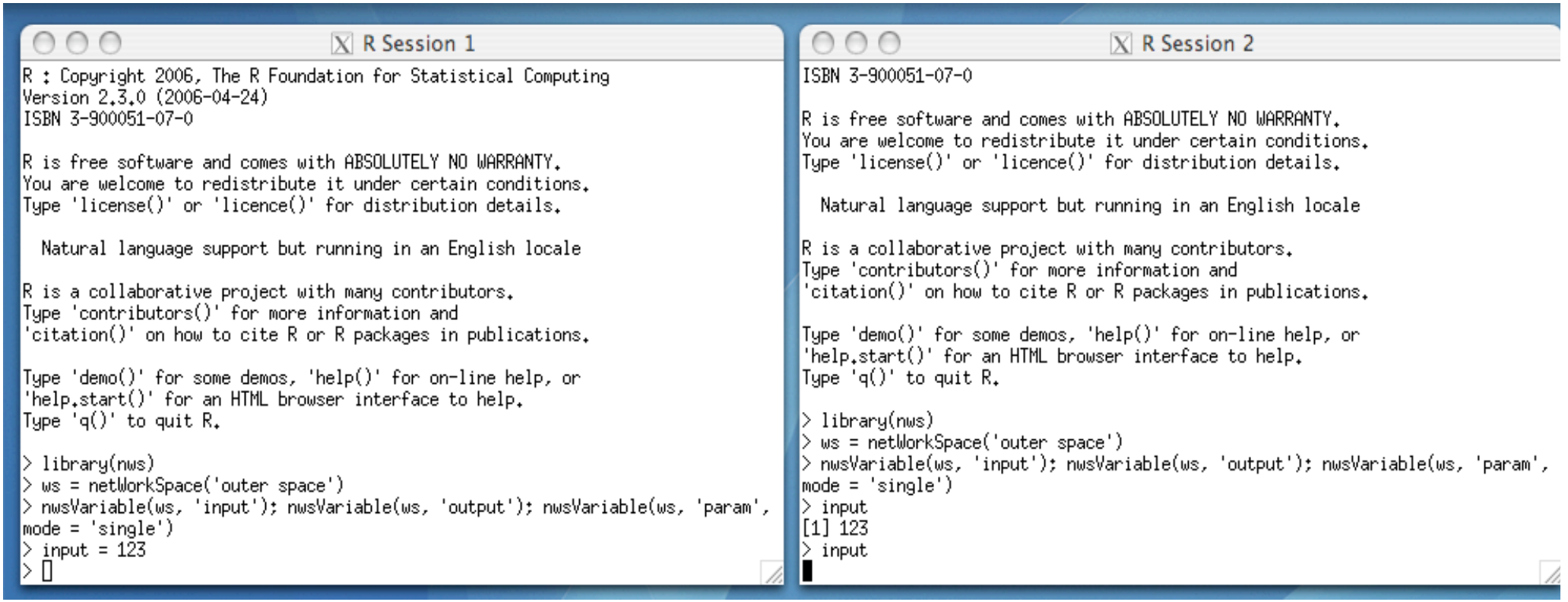
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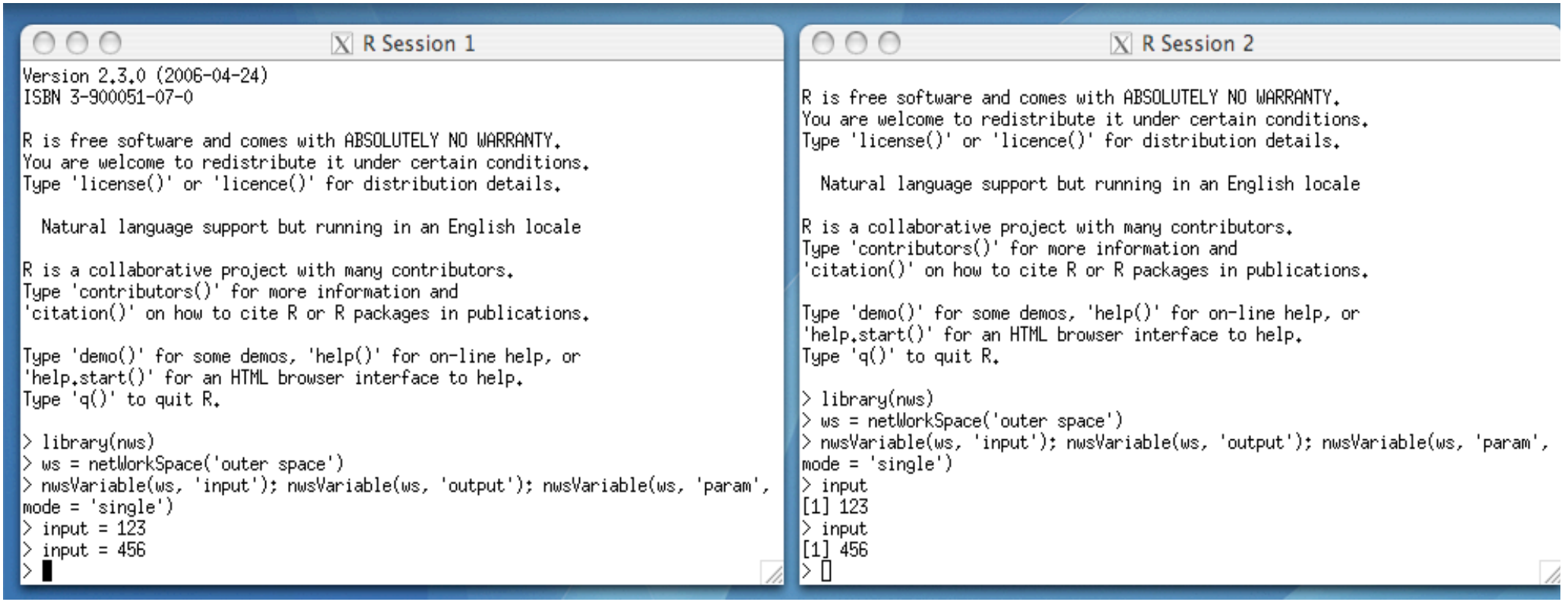
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> input = 456
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> input
[1] 456
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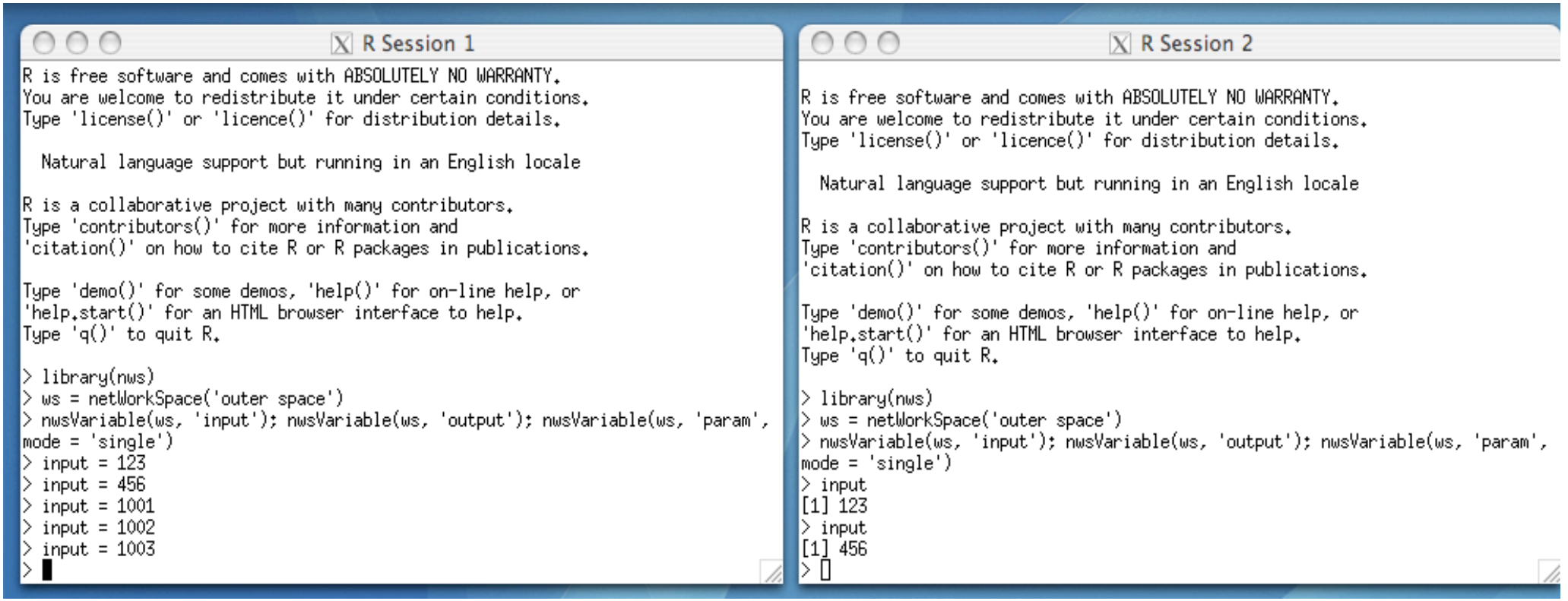
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> input = 1003
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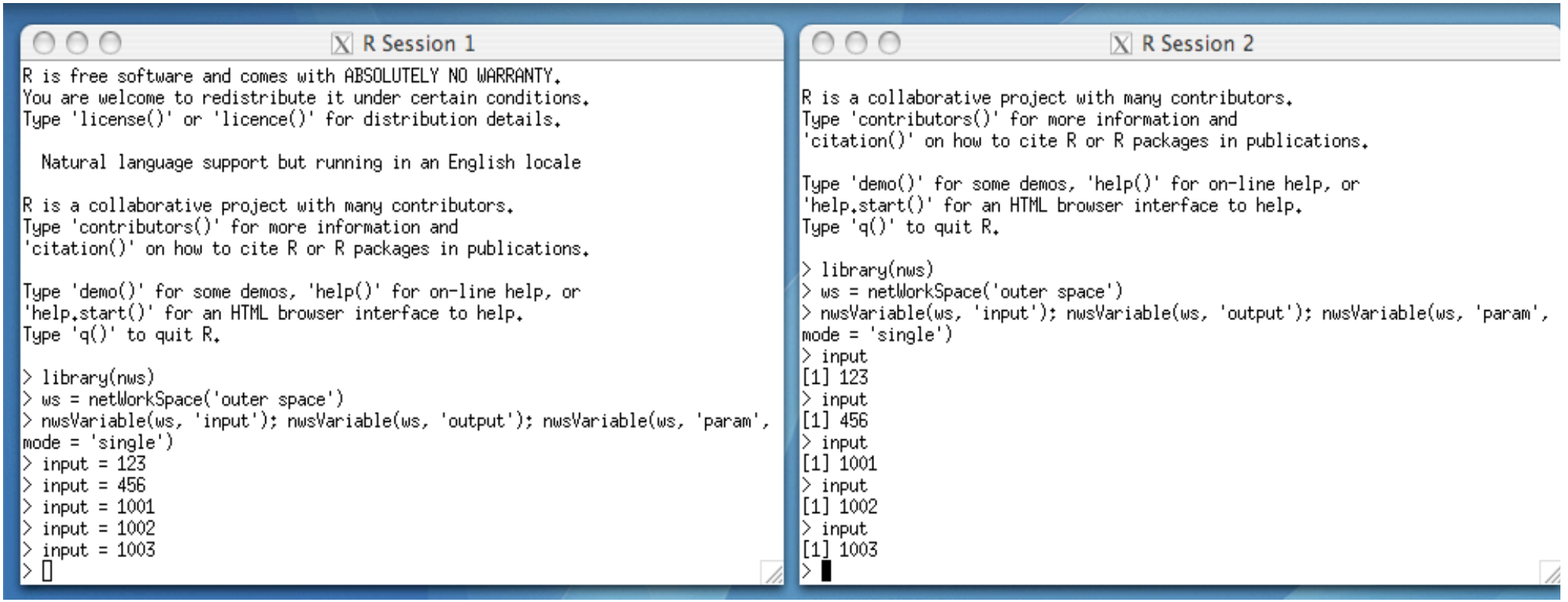
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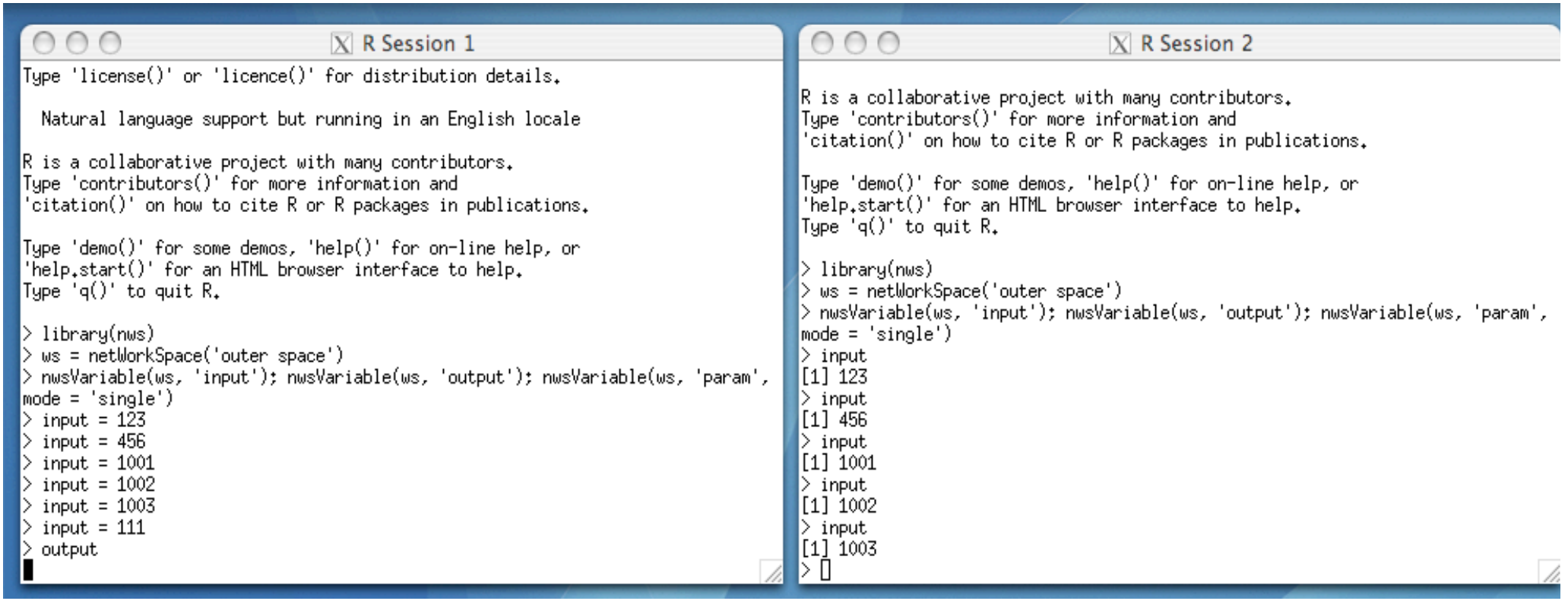
[1] 1001
> input
[1] 1002
> input
[1] 1003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> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
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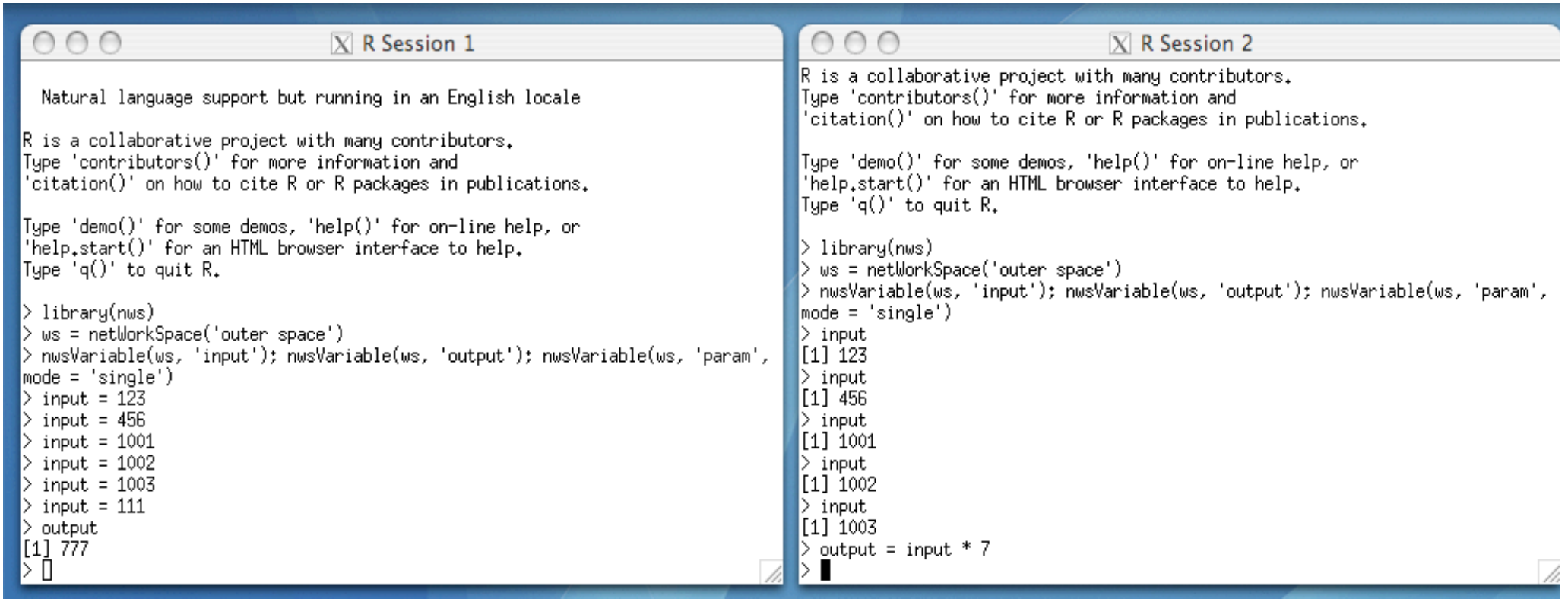
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003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mode = 'single')
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
>
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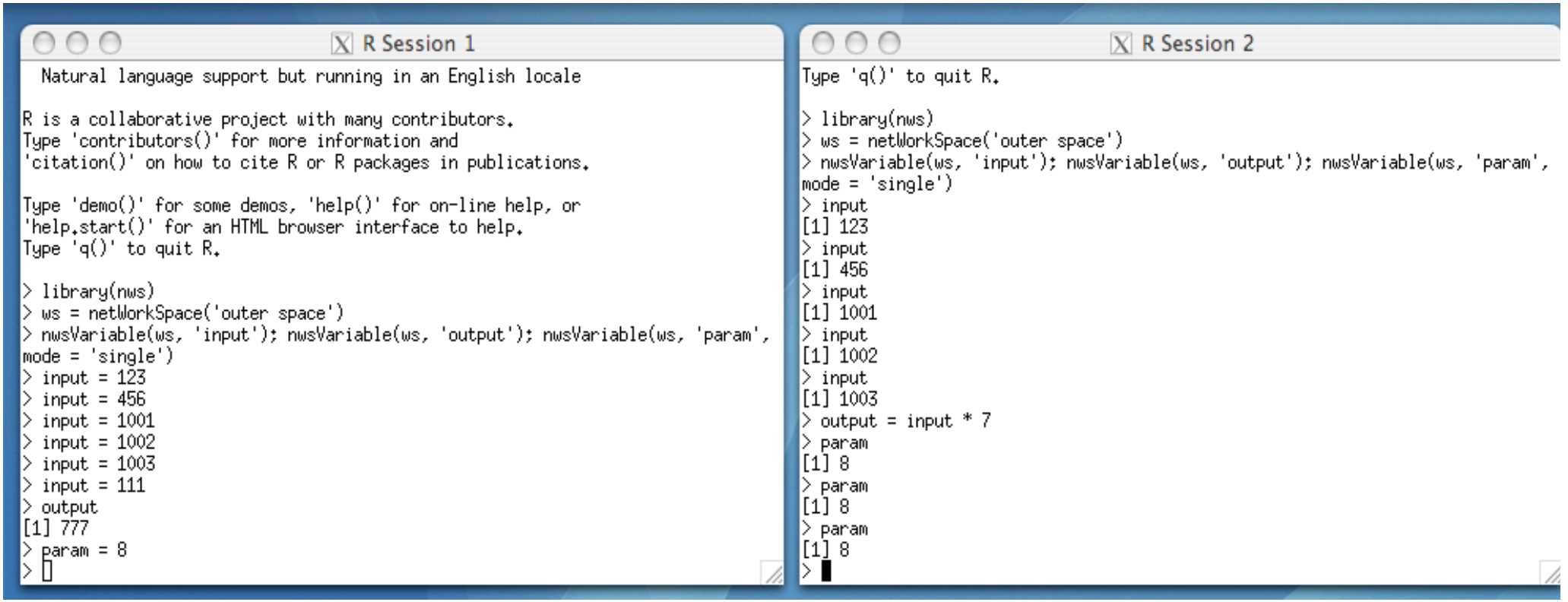
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output = input * 7
>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> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
>
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> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
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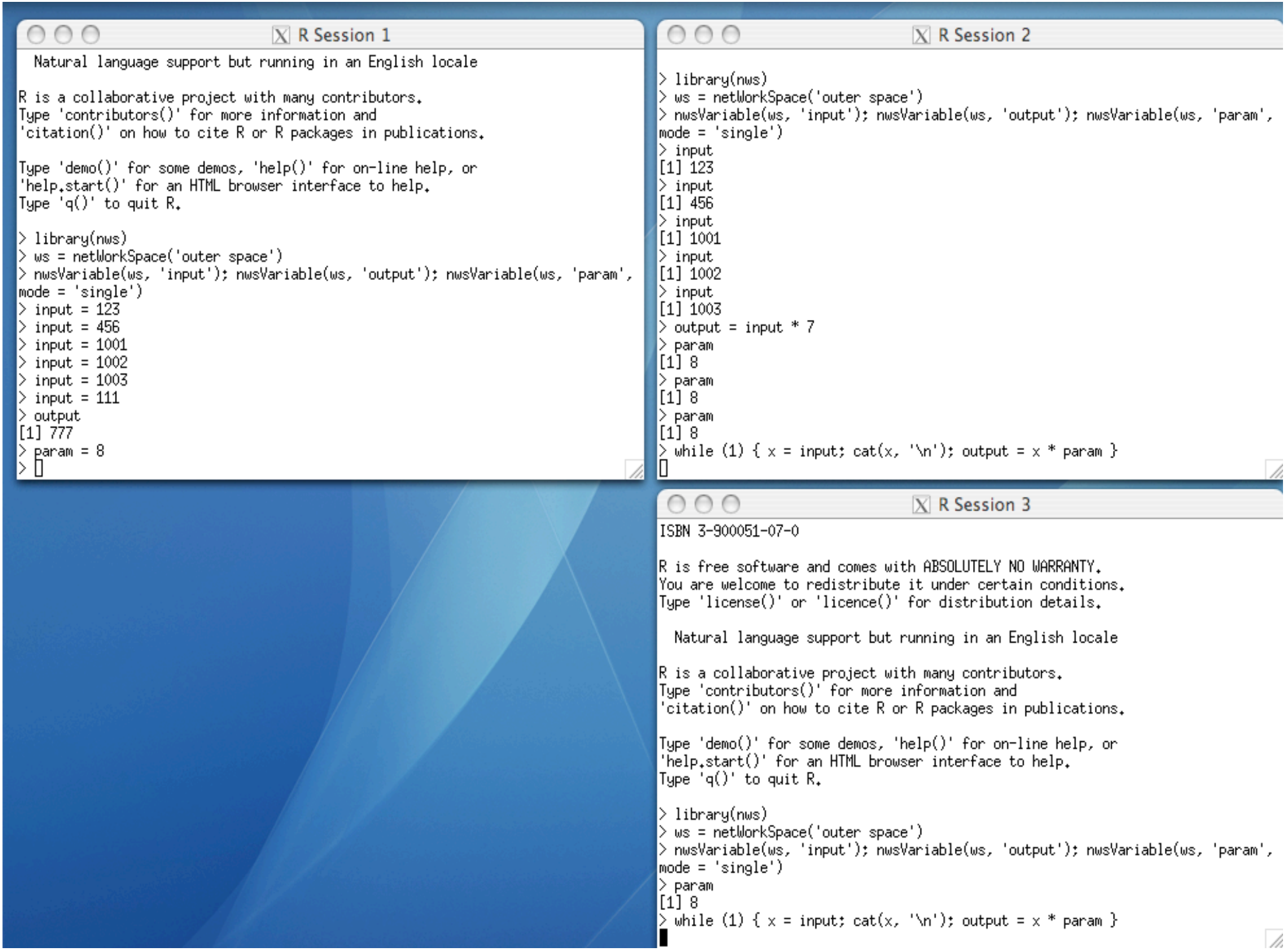
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output = input * 7
> param
[1] 8
> param
[1] 8
> param
[1] 8
>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> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
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> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output = input * 7
> param
[1] 8
> param
[1] 8
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
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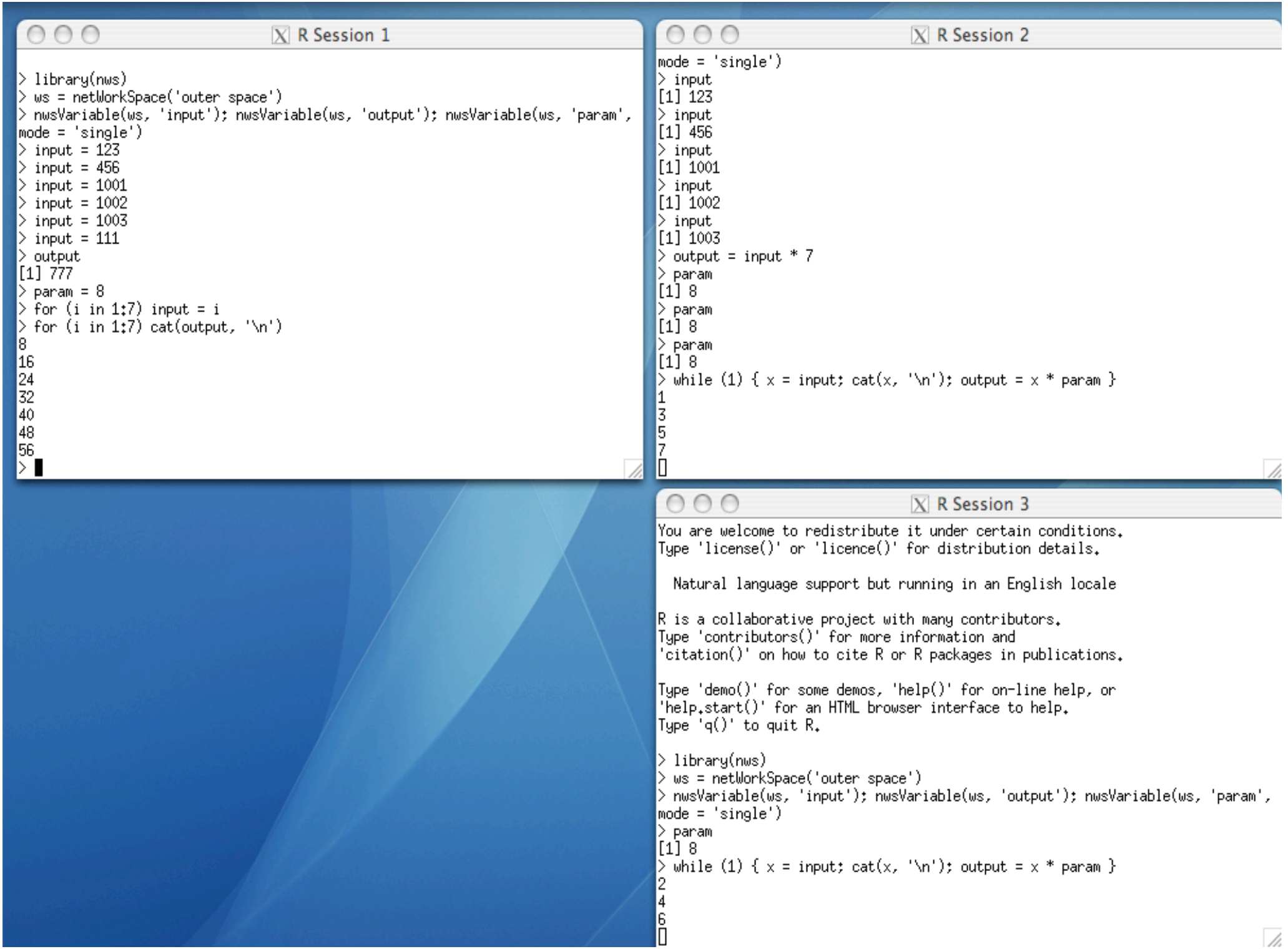
mode = 'single')
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }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> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
> for (i in 1:7) input = i
> for (i in 1:7) cat(output, '\n')
8
16
24
32
40
48
56
>
R Session 2
mode = 'single')
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output = input * 7
> param
[1] 8
> param
[1] 8
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
1
3
5
7
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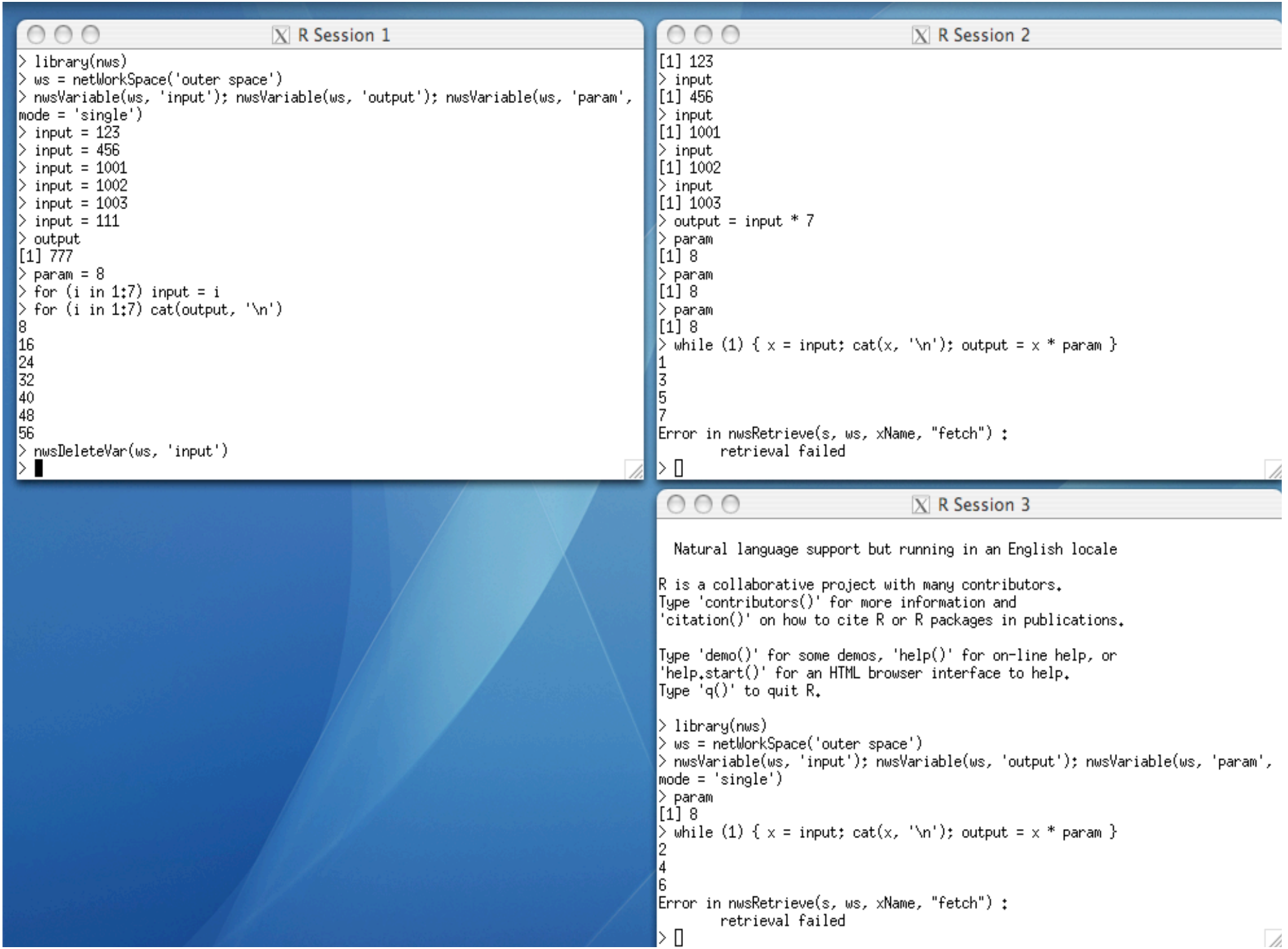
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
2
4
6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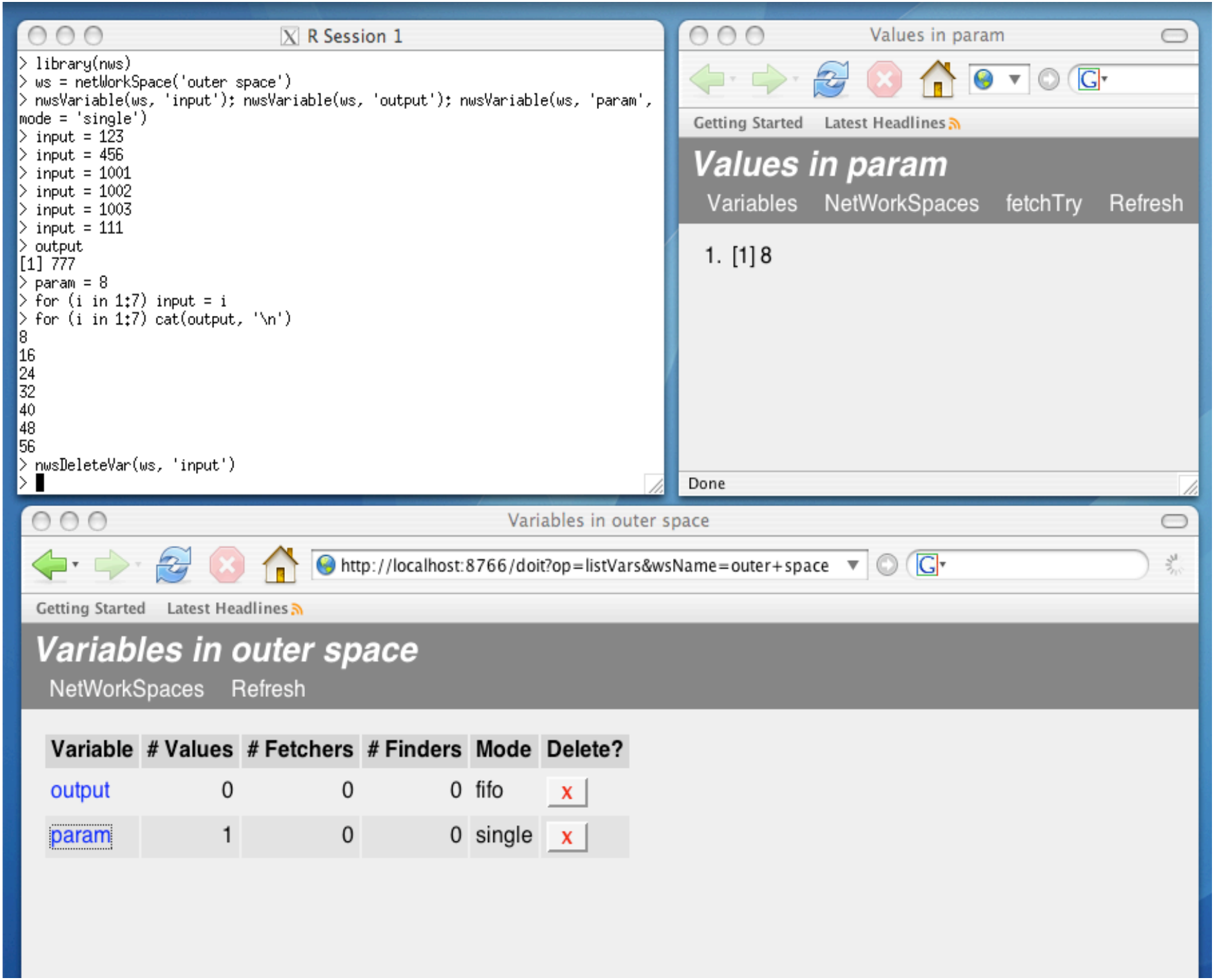
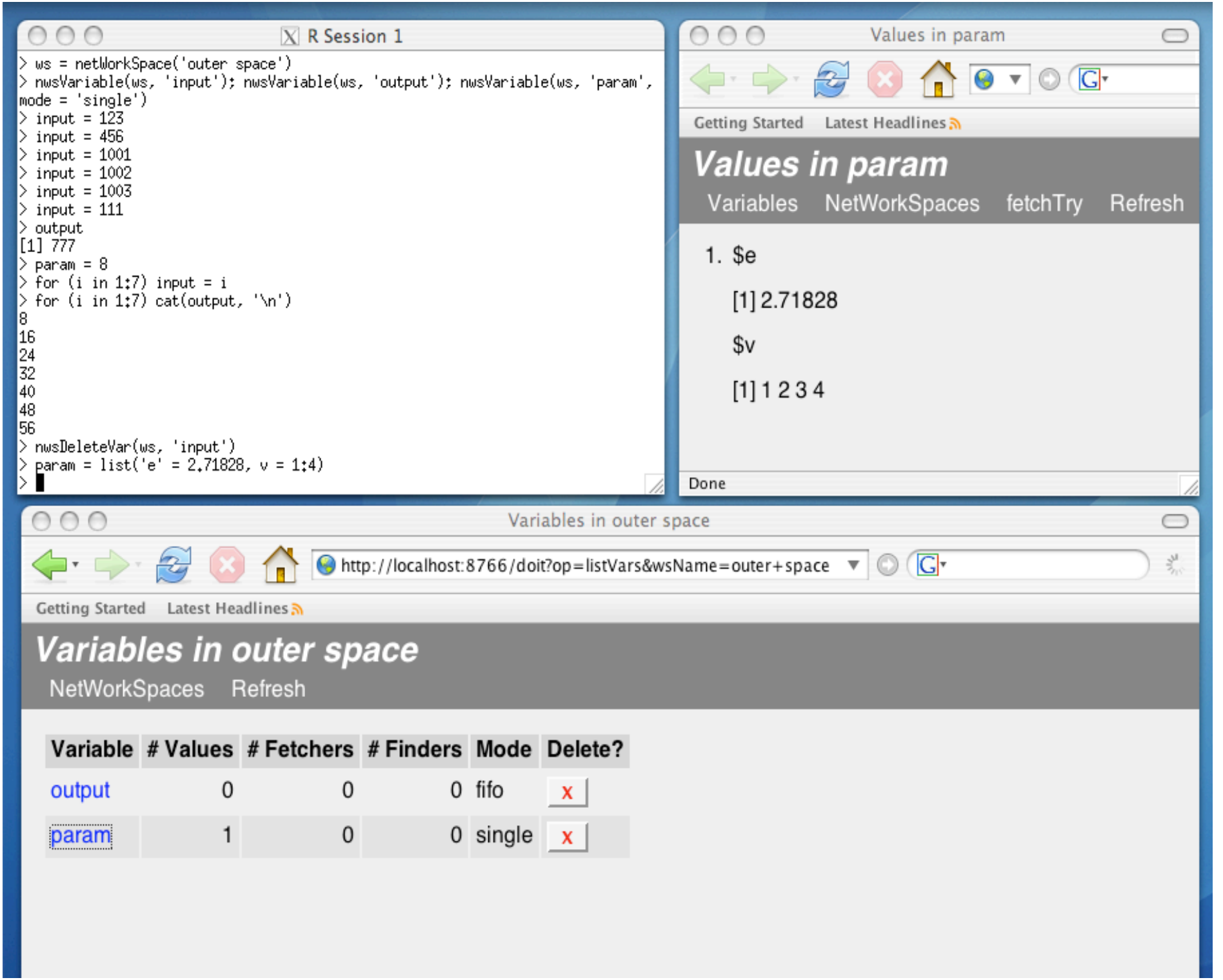
> output
[1] 777
> param = 8
> for (i in 1:7) input = i
> for (i in 1:7) cat(output, '\n')
8
16
24
32
40
48
56
> nwsDeleteVar(ws, 'input')
R Session 2
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output = input * 7
> param
[1] 8
> param
[1] 8
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
1
3
5
7
Error in nwsRetrieve(s, ws, xName, "fetch") :
retrieval failed
R Session 3
Natural language support but running in an English locale
R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.
> library(nws)
> ws = netWorkSpace('outer space')
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
mode = 'single')
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
2
4
6
Error in nwsRetrieve(s, ws, xName, "fetch") :
retrieval failed


R Session 1
> library(nws)
> ws = netWorkSpace('outer space')
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
mode = 'single')
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
> for (i in 1:7) input = i
> for (i in 1:7) cat(output, '\n')
8
16
24
32
40
48
56
> nwsDeleteVar(ws, 'input')
>
Values in param
Getting Started
Latest Headlines
Values in param
Variables
NetWorkSpaces
fetchTry
Refresh
1. [1] 8
Done
Variables in outer space
http://localhost:8766/doit?op=listVars&wsName=outer+space
Getting Started
Latest Headlines
Variables in outer space
NetWorkSpaces
Refresh
Variable
Values
Fetchers
Finders
Mode
Delete?
output
0
0
0
fifo
x
param
1
0
0
single
x


R Session 1
> ws = netWorkSpace('outer space')
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param', mode = 'single')
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
> for (i in 1:7) input = i
> for (i in 1:7) cat(output, '\n')
8
16
24
32
40
48
56
> nwsDeleteVar(ws, 'input')
> param = list('e' = 2.71828, v = 1:4)
Values in param
Getting Started
Latest Headlines
Values in param
Variables
NetWorkSpaces
fetchTry
Refresh
1. $e
[1] 2.71828
$v
[1] 1 2 3 4
Done
Variables in outer space
http://localhost:8766/doit?op=listVars&wsName=outer+space
Getting Started
Latest Headlines
Variables in outer space
NetWorkSpaces
Refresh
Variable
Values
Fetchers
Finders
Mode
Delete?
output
0
0
0
fifo
x
param
1
0
0
single
x

Coordination via NetWorkSpaces

- Shared Access: Communication.
- Blocking References: Synchronization.
- Coordination provided within the context of the existing, familiar concept of a “workspace”.

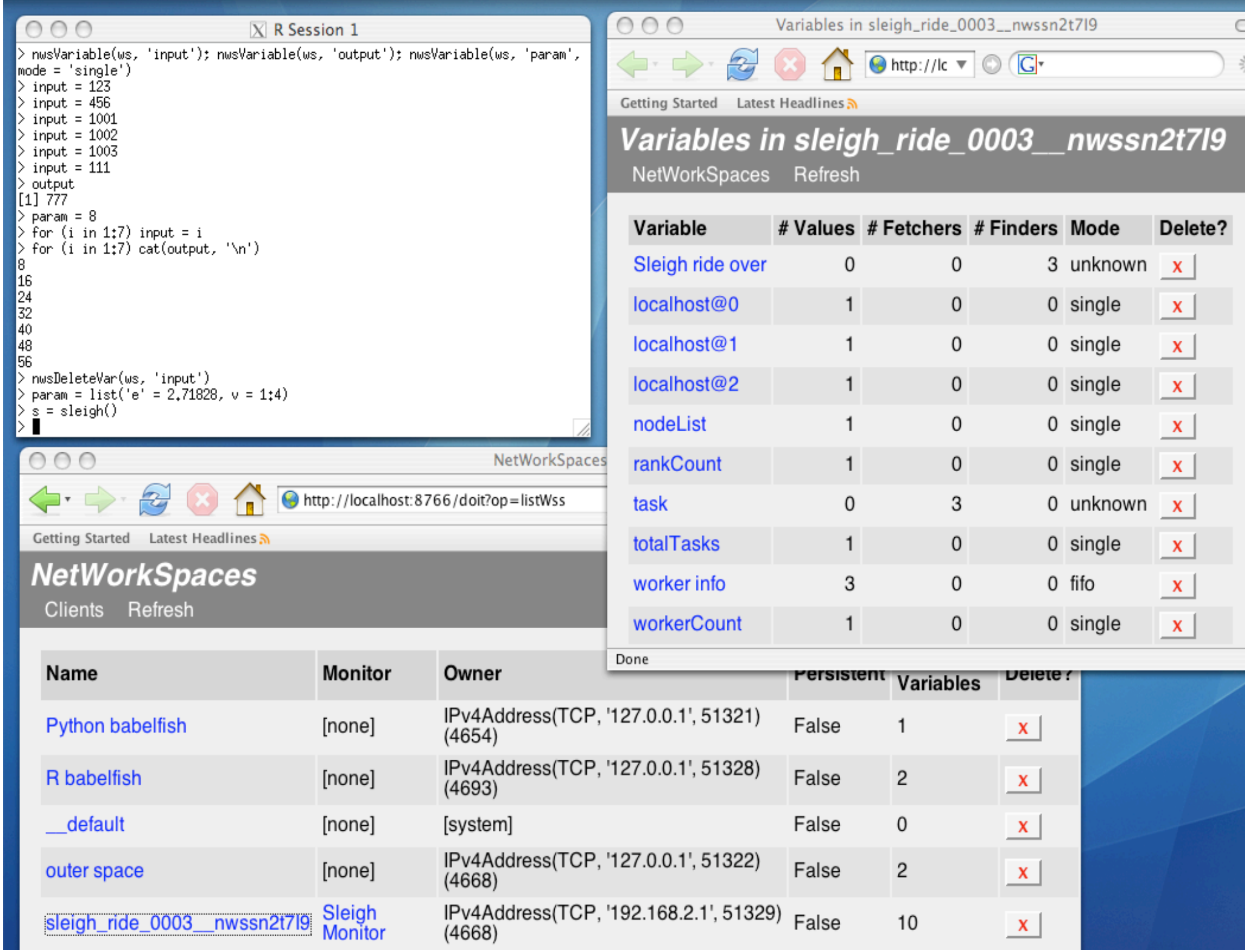
- Coordination data has independent existence

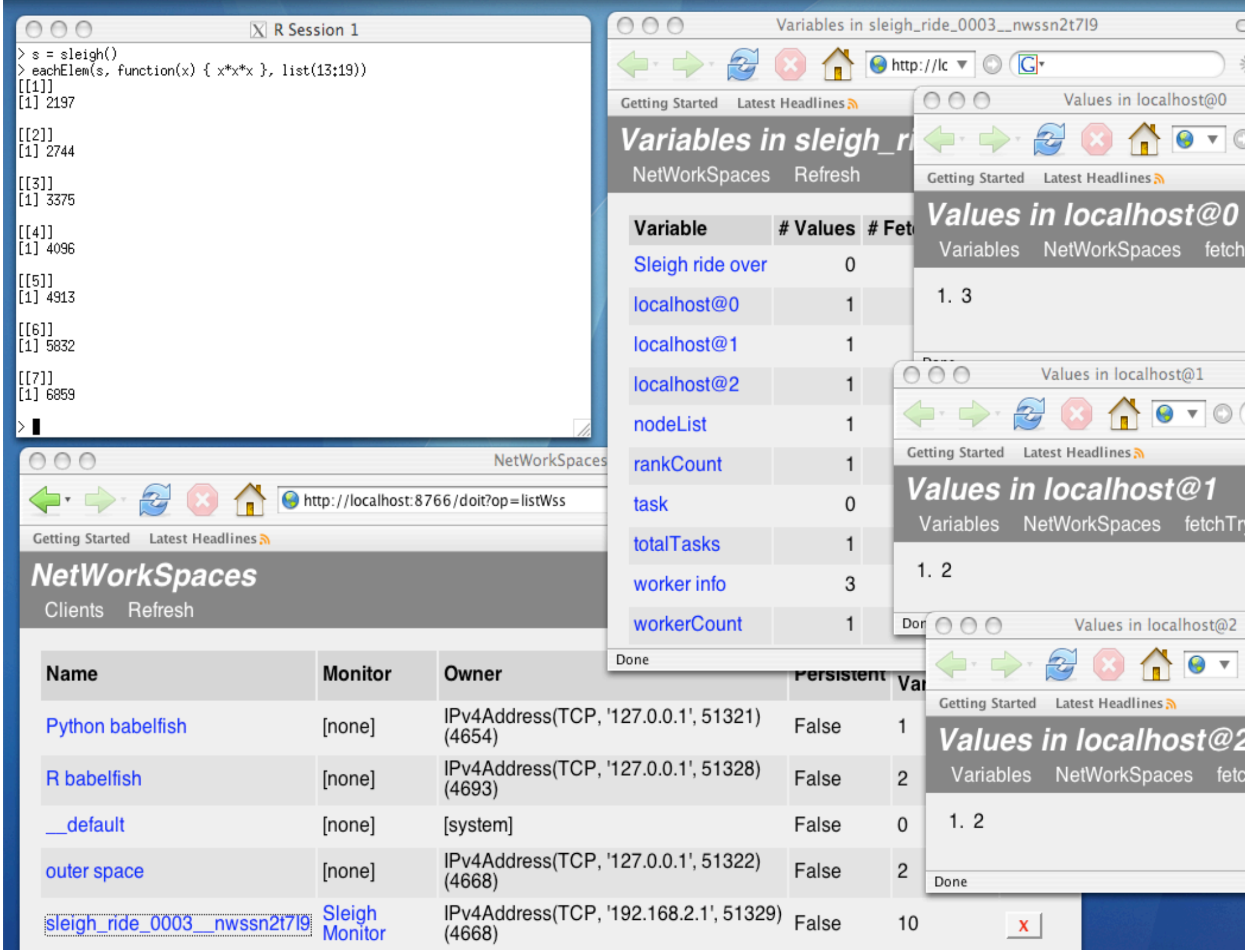
Benefits

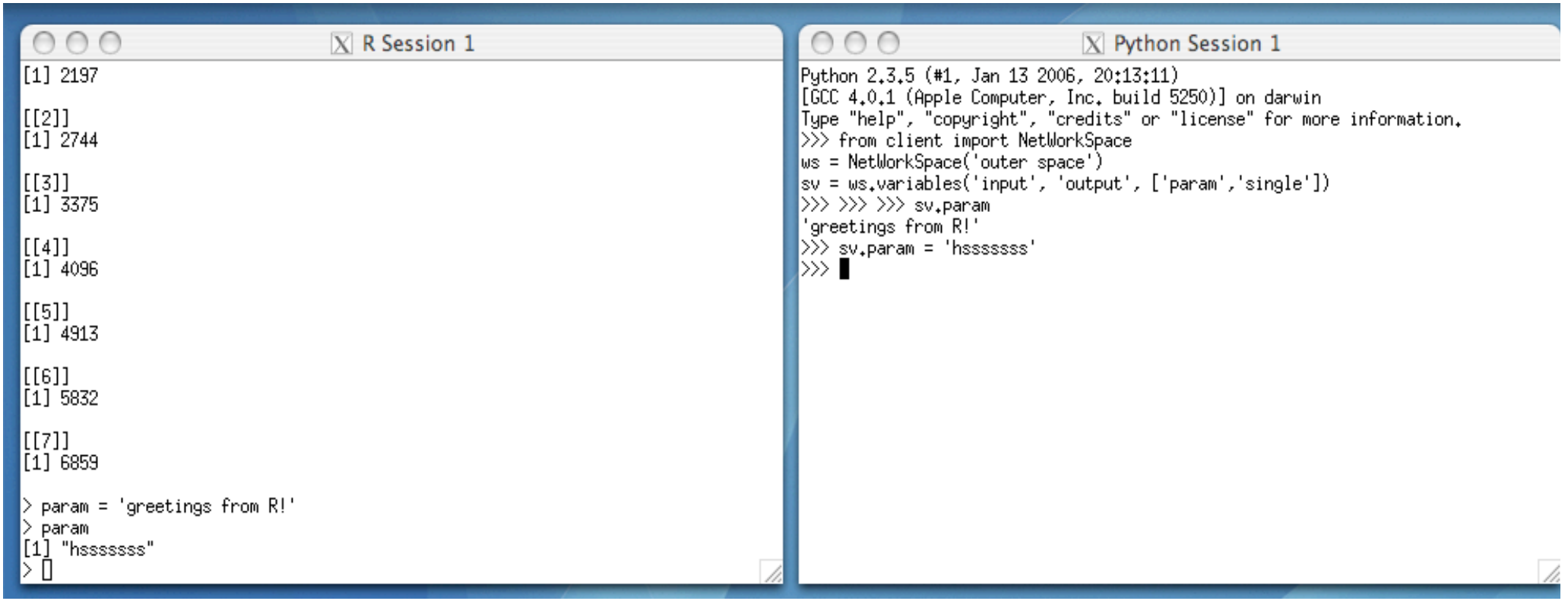
- Simplifies development:
  - Familiar conceptual foundation
  - Uncoupling in space and time
  - Anonymity
- Promotes flexibility:
  - Dynamic processing ensembles
  - Cross platform
  - Cross environment

Sleigh

- Inspired by snow (Tierney, Rossini, Li, Sevcikova), but snow and sleigh differ in many ways.
- Supports “parallel” apply.
- Implemented on top of NetWorkSpaces.
- Vehicle for launching codes that explicitly use NetWorkSpaces for coordination.


R Session 1
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param', mode = 'single')
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
> for (i in 1:7) input = i
> for (i in 1:7) cat(output, '\n')
8
16
24
32
40
48
56
> nwsDeleteVar(ws, 'input')
> param = list('e' = 2.71828, v = 1:4)
> s = sleigh()
Variables in sleigh_ride_0003__nwssn2t7l9
Getting Started
Latest Headlines
Variables in sleigh_ride_0003__nwssn2t7l9
NetWorkSpaces
Refresh
Variable
Values
Fetchers
Finders
Mode
Delete?
Sleigh ride over
0
0
3
unknown
localhost@0
1
0
0
single
localhost@1
1
0
0
single
localhost@2
1
0
0
single
nodeList
1
0
0
single
rankCount
1
0
0
single
task
0
3
0
unknown
totalTasks
1
0
0
single
worker info
3
0
0
fifo
workerCount
1
0
0
single
Done
NetWorkSpaces
http://localhost:8766/doit?op=listWss
Getting Started
Latest Headlines
NetWorkSpaces
Clients
Refresh
Name
Monitor
Owner
Persistent
Variables
Delete?
Python babelfish
[none]
IPv4Address(TCP, '127.0.0.1', 51321) (4654)
False
1
R babelfish
[none]
IPv4Address(TCP, '127.0.0.1', 51328) (4693)
False
2
__default
[none]
[system]
False
0
outer space
[none]
IPv4Address(TCP, '127.0.0.1', 51322) (4668)
False
2
sleigh_ride_0003__nwssn2t7l9
Sleigh Monitor
IPv4Address(TCP, '192.168.2.1', 51329) (4668)
False
10


R Session 1
> s = sleigh()
> eachElem(s, function(x) { x*x*x }, list(13:19))
[[1]]
[1] 2197
[[2]]
[1] 2744
[[3]]
[1] 3375
[[4]]
[1] 4096
[[5]]
[1] 4913
[[6]]
[1] 5832
[[7]]
[1] 6859
Variables in sleigh_ride_0003__nwssn2t7l9
Variables in sleigh_ri
NetWorkSpaces Refresh
Variable # Values
Sleigh ride over 0
localhost@0 1
localhost@1 1
localhost@2 1
nodeList 1
rankCount 1
task 0
totalTasks 1
worker info 3
workerCount 1
Done
Values in localhost@0
Values in localhost@0
Variables NetWorkSpaces fetch
1. 3
Values in localhost@1
Values in localhost@1
Variables NetWorkSpaces fetchTr
1. 2
Values in localhost@2
Values in localhost@2
Variables NetWorkSpaces fetc
1. 2
Done
NetWorkSpaces
http://localhost:8766/doit?op=listWss
NetWorkSpaces
Clients Refresh
Name Monitor Owner Persistent
Python babelfish [none] IPv4Address(TCP, '127.0.0.1', 51321) (4654) False 1
R babelfish [none] IPv4Address(TCP, '127.0.0.1', 51328) (4693) False 2
__default [none] [system] False 0
outer space [none] IPv4Address(TCP, '127.0.0.1', 51322) (4668) False 2
sleigh_ride_0003__nwssn2t7l9 Sleigh Monitor IPv4Address(TCP, '192.168.2.1', 51329) (4668) False 10
X


R Session 1
[1] 2197
[[2]]
[1] 2744
[[3]]
[1] 3375
[[4]]
[1] 4096
[[5]]
[1] 4913
[[6]]
[1] 5832
[[7]]
[1] 6859
> param = 'greetings from R!'
> param
[1] "hsssssss"
>
Python Session 1
Python 2.3.5 (#1, Jan 13 2006, 20:13:11)
[GCC 4.0.1 (Apple Computer, Inc. build 5250)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> from client import NetWorkSpace
ws = NetWorkSpace('outer space')
sv = ws.variables('input', 'output', ['param','single'])
>>> >>> >>> sv.param
'greetings from R!'
>>> sv.param = 'hsssssss'
>>>

- MATLAB, octave, python, perl, ruby, …
- Software available from: http://nws-r.sourceforge.net
  (open source for open source systems; commercial for commercial systems: www.lindaspaces.com)
- API used in this talk is a “teaser”. More serious projects use a richer, but more verbose, API.