APPENDIX 3
SEED AND GROUP ANALYSES

A3.1 Introduction

This appendix presents the detailed results from the seed and group information integration analyses.

A3.2 Complexes Found using Seed Expansion Method

This section presents the complexes that were found in the network using the seed expansion method. All of these results were brought together in the general discussion of the information integration of the network in Section 7.4.6. To present the results as clearly as possible the neuron groups in the figures are labelled using the IDs in Table A3.1, which correspond to the IDs that were used for these neuron groups in the database. The full results are included as XML files in the Supporting Materials.

ID	Neuron Group
24	Vision Input
28	Red Sensorimotor
29	Blue Sensorimotor
62	Emotion
34	Inhibition
61	Motor Cortex
60	Motor Integration
54	Eye Pan
55	Eye Tilt
53	Motor Output

Table A3.1. Neuron group IDs

A3.2.1 Vision Input

Since this layer contained over 8,000 neurons, it was decided to start with a maximum subset size of 50. All of the seeds in this neuron group expanded to small complexes of approximately 30 neurons with Φ ranging from 75-91. Most of the neurons in these complexes were in Inhibition, as shown in Figure A3.1. The analysis took 4.5 days.

Parameter	Value
Max number of bipartitions per level	5
Percentage of bipartition levels	50
Expansion rate per connection group	1
Maximum subset size	50
Maximum number of consecutive expansion failures per connection group	5
Only examine equal bipartitions	false

Table A3.2. Parameters for seed-based Vision Input analysis
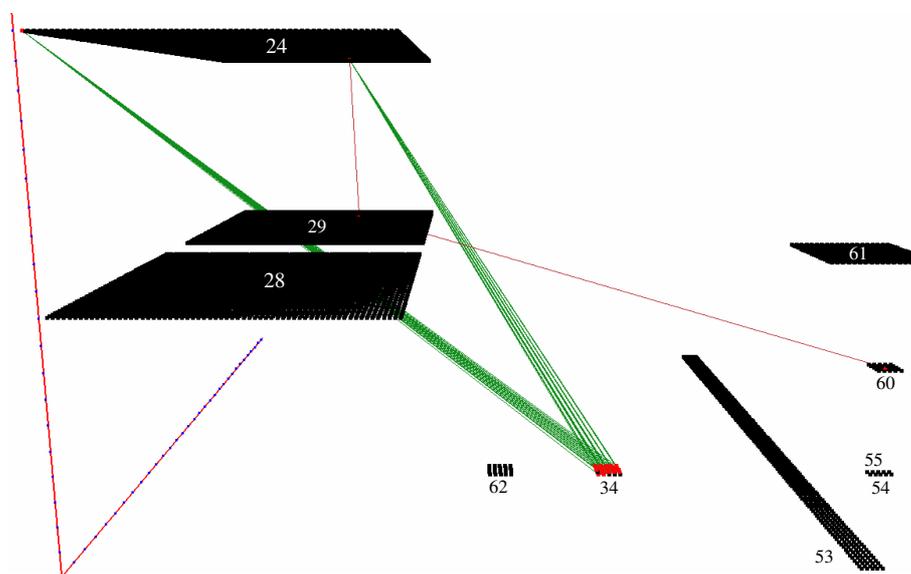

Figure A3.1. Typical complex found during expansion of seeds in Vision Input

A3.2.2 Blue Sensorimotor

This was a large layer with over 4,000 neurons, and so it was decided to start with a maximum subset size of 50. About 2500 of the seeds in this layer expanded into small complexes with Φ

ranging from 26-93. Most of the neurons in these complexes were in Inhibition, as shown in Figure A3.2. The analysis took 2 days.

Parameter	Value
Max number of bipartitions per level	5
Percentage of bipartition levels	50
Expansion rate per connection group	1
Maximum subset size	50
Maximum number of consecutive expansion failures per connection group	5
Only examine equal bipartitions	false

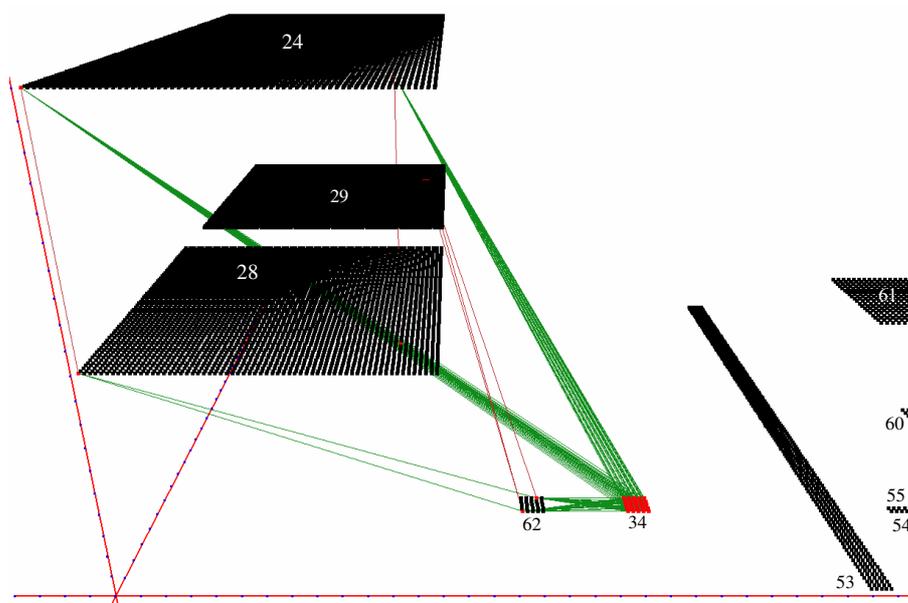**Table A3.3**. Parameters for seed-based Blue Sensorimotor analysis

Figure A3.2. Typical complex found during seed-based Blue Sensorimotor analysis

A3.2.3 Red Sensorimotor

This was a large layer with over 4,000 neurons, and so it was decided to start with a maximum subset size of 50. About 3200 of the seeds in this layer expanded into small complexes with Φ ranging from 26-93. Most of the neurons in these complexes were in Inhibition, as shown in Figure A3.3. The analysis took 2.5 days.

Parameter	Value
Max number of bipartitions per level	5
Percentage of bipartition levels	50
Expansion rate per connection group	1
Maximum subset size	50
Maximum number of consecutive expansion failures per connection group	5
Only examine equal bipartitions	false

Table A3.4. Parameters for seed-based Red Sensorimotor analysis
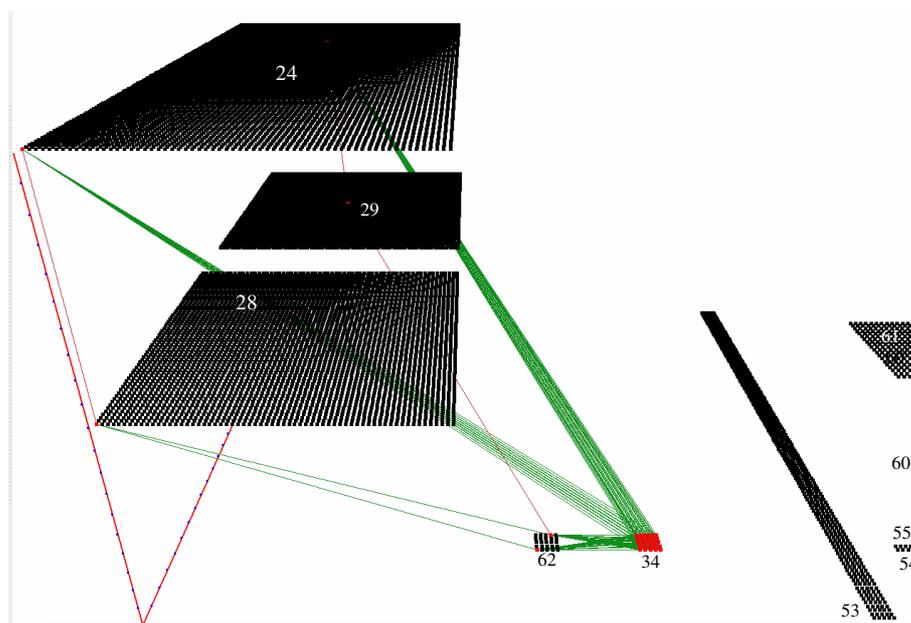

Figure A3.3. Typical complex found during seed-based Red Sensorimotor analysis

A3.2.4 Inhibition

The seeds in Inhibition expanded their connections with Vision Input into a subset that had a relatively low Φ of about 6 (see Figure A3.4). Each expansion increased the Φ value by a small amount, but since there were 8192 connections between each neuron in Inhibition and Vision Input, all of the subsets expanded beyond the maximum subset size of 150. After eleven seeds had been expanded without a complex being found, the expansion rate was changed to 10 to speed up the analysis, which took 3.5 days.

Parameter	Value
Max number of bipartitions per level	25
Percentage of bipartition levels	100
Expansion rate per connection group	10
Maximum subset size	150
Maximum number of consecutive expansion failures per connection group	10
Only examine equal bipartitions	false

Table A3.5. Parameters for seed-based Inhibition analysis
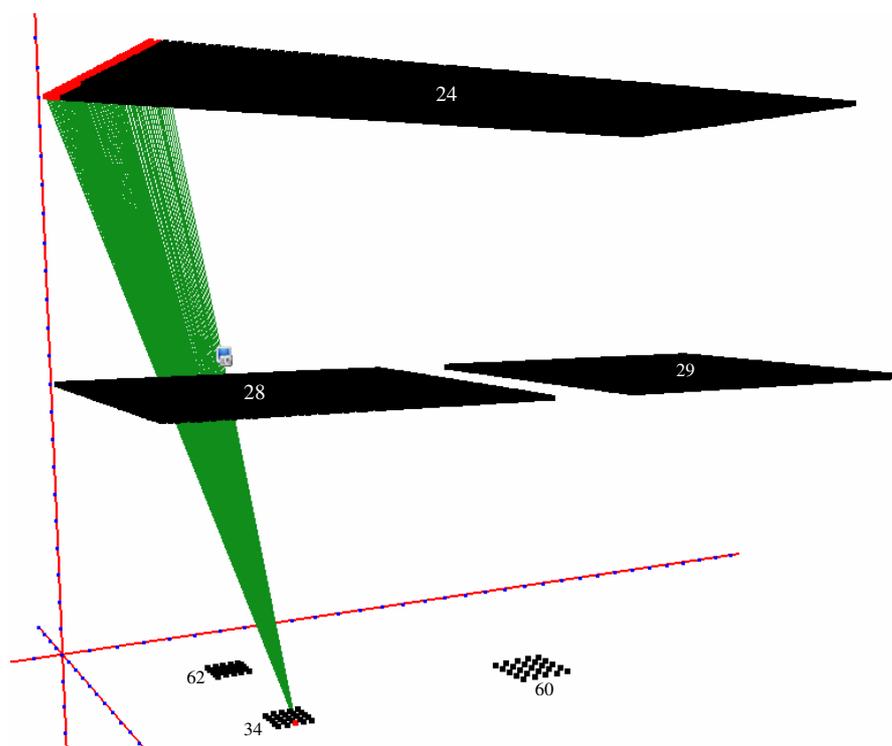

Figure A3.4. Subset during seed-based Inhibition analysis

A3.2.5 Motor Output

Most of the seeds in this layer expanded into a complex with 23 neurons and $\Phi = 56.8$ that included most of Inhibition (see Figure A3.5). A number of seeds also expanded into complexes with 71-91 neurons that included a number of different neuron groups and had Φ ranging from 80-103. One of these turned out to be the main complex, which is shown in Figure A3.6. Only one seed expanded beyond the maximum subset size of 150 neurons. The analysis took 7.5 days.

Parameter	Value
Max number of bipartitions per level	25
Percentage of bipartition levels	100
Expansion rate per connection group	1
Maximum subset size	150
Maximum number of consecutive expansion failures per connection group	10
Only examine equal bipartitions	false

Table A3.6. Parameters for seed-based Motor Output analysis
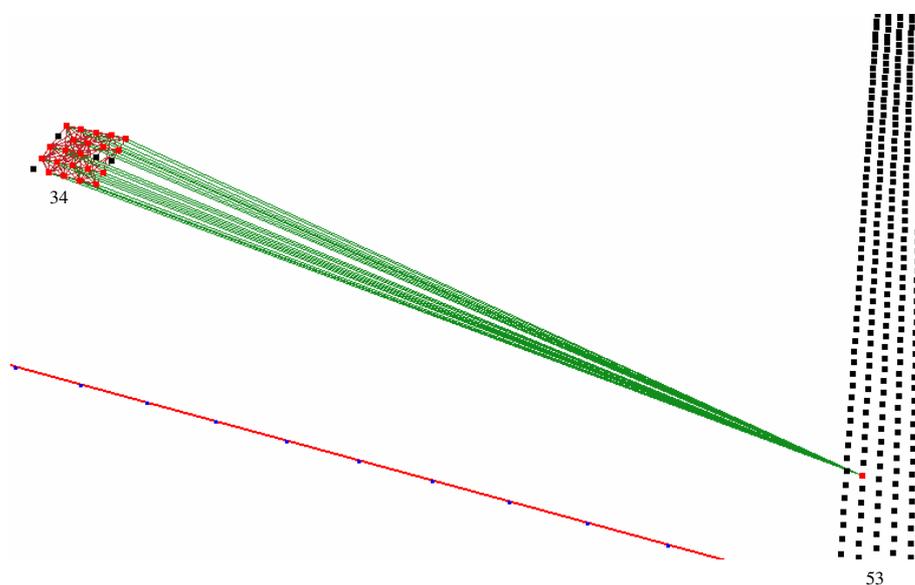

Figure A3.5. Typical small complex found during seed-based Motor Output analysis
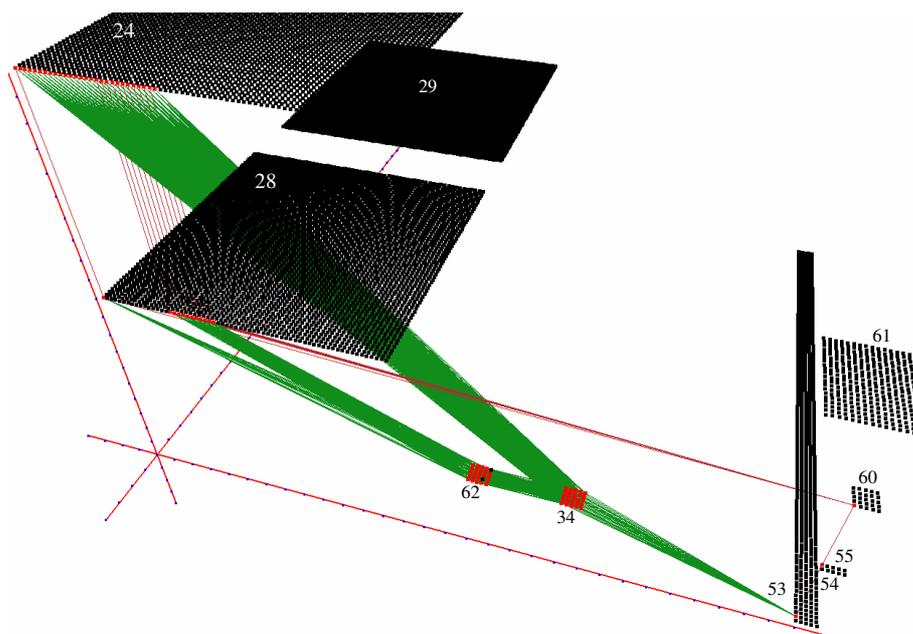
Figure A3.6. Larger complex found during seed-based Motor Output analysis. This is the main complex of the network.

A3.2.6 Eye Pan

One of the seeds in this layer expanded to more than 150 neurons and three seeds expanded to complexes with 12 neurons and $\Phi = 4.7$, an example of which is shown in Figure A3.7. The fifth seed expanded to a complex with 77 neurons and $\Phi = 59.2$, which included neurons from a number of different groups including Inhibition. The analysis took 4 days.

Parameter	Value
Max number of bipartitions per level	50
Percentage of bipartition levels	100
Expansion rate per connection group	1
Maximum subset size	150
Maximum number of consecutive expansion failures per connection group	10
Only examine equal bipartitions	false

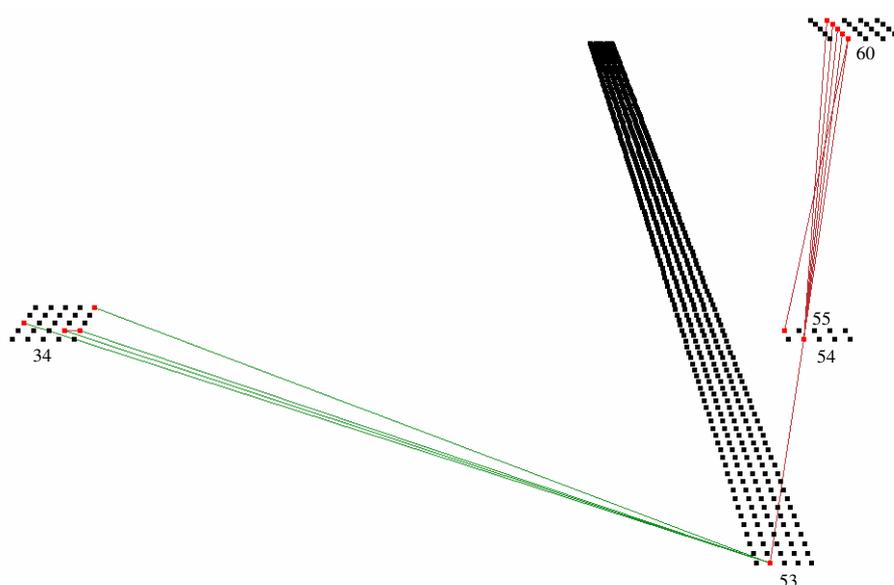**Table A3.7**. Parameters for seed-based Eye Pan analysis

Figure A3.7. Typical small complex found during seed-based Eye Pan analysis

A3.2.7 Eye Tilt

One of the seeds in this layer expanded into a complex with 69 neurons and $\Phi = 46$, which is shown in Figure A3.8. The other four seeds expanded into complexes with 12 neurons and $\Phi = 4.7$, an example of which is shown in Figure A3.9. The analysis took 9 hours.

Parameter	Value
Max number of bipartitions per level	50
Percentage of bipartition levels	100
Expansion rate per connection group	1
Maximum subset size	150
Maximum number of consecutive expansion failures per connection group	10
Only examine equal bipartitions	false

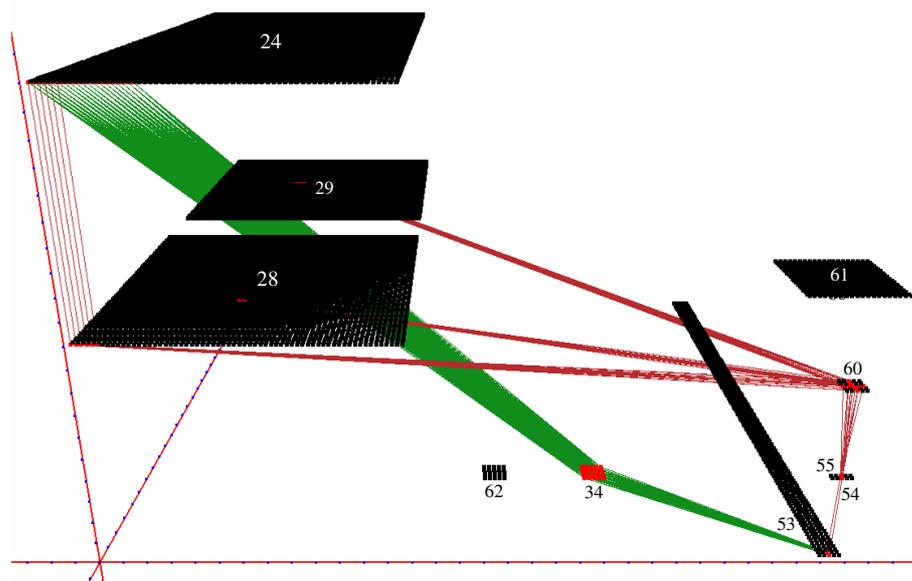**Table A3.8**. Parameters for seed-based Eye Tilt analysis

Figure A3.8. Large complex found during seed-based Eye Tilt analysis
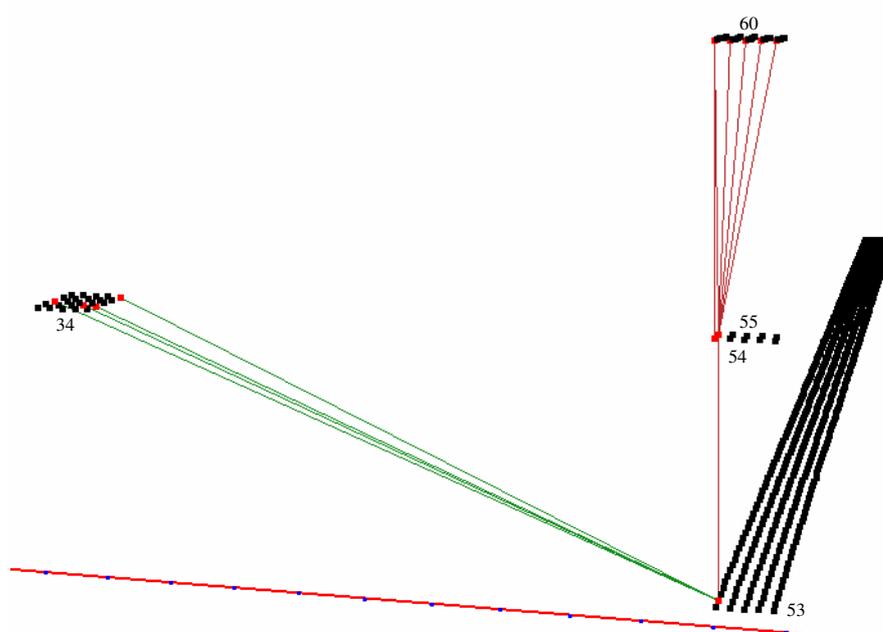

Figure A3.9. Small complex found during seed-based Eye Tilt analysis

A3.2.8 Motor Integration

12 of the seeds expanded into small complexes with 4 neurons and $\Phi = 4.0$, as shown in Figure A3.10. The rest of the seeds expanded into subsets larger than 150 neurons with higher values of Φ, as shown in Figure A3.11. The analysis took 9.5 days.

Parameter	Value
Max number of bipartitions per level	25
Percentage of bipartition levels	100
Expansion rate per connection group	1
Maximum subset size	150
Maximum number of consecutive expansion failures per connection group	10
Only examine equal bipartitions	false

Table A3.9. Parameters for seed-based Motor Integration analysis
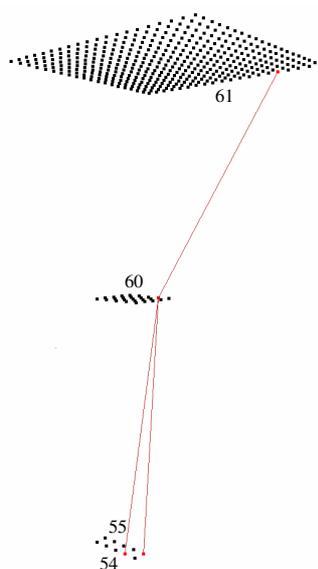

Figure A3.10. Small complex found during seed-based Motor Integration analysis
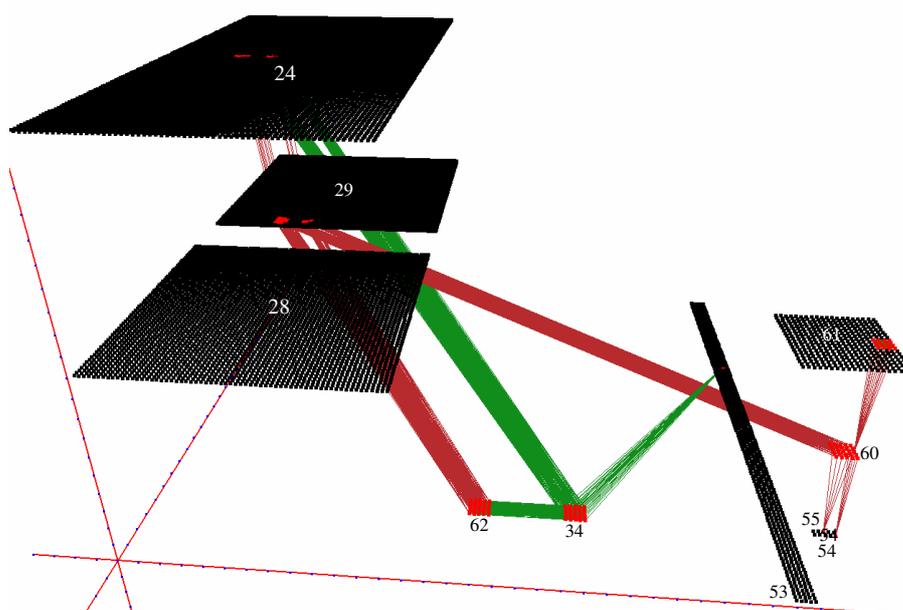

Figure A3.11. Subset during seed-based Motor Integration analysis

A3.2.9 Motor Cortex

This layer has 400 neurons, and so it was decided to start with a maximum subset size of 50. Since this layer has a large number of recurrent connections, it was anticipated that the seeds would expand into complexes that included the whole of Motor Cortex and possibly more. During the analysis all of the seeds in this neuron group expanded into subsets greater than 50 neurons.

Parameter	Value
Max number of bipartitions per level	10
Percentage of bipartition levels	100
Expansion rate per connection group	1
Maximum subset size	50
Maximum number of consecutive expansion failures per connection group	10
Only examine equal bipartitions	false

Table A3.10. Parameters for seed-based Motor Cortex analysis

A3.2.10 Emotion

Most of the seeds in this layer expanded into a complex of 25 neurons that included the whole of Emotion and had $\Phi = 79.9$. One seed expanded into a complex with 39 neurons and $\Phi = 74.4$. The analysis took approximately 20 hours.

Parameter	Value
Max number of bipartitions per level	50
Percentage of bipartition levels	100
Expansion rate per connection group	1
Maximum subset size	200
Maximum number of consecutive expansion failures per connection group	10
Only examine equal bipartitions	false

Table A3.11. Parameters for seed-based Emotion analysis

A3.3 Calculation of Φ on Neuron Groups(s)

Although 14,528 complexes were identified with the seed expansion method, the limit on subset size meant that many complexes could not be identified and the information integration of many neurons was not known – a problem that was particularly apparent in Motor Cortex and Motor Integration. To close these gaps in the analysis, the Φ calculation was also run on individual neuron groups and on combinations of connected neuron groups, up to a maximum size of about 700 neurons, which was the largest subset that could be analyzed in the time available. Neuron groups without recurrent connections – Blue Sensorimotor, Red Sensorimotor, Vision Input, Eye Pan, Eye Tilt, Motor Integration, and Motor Output - were only analyzed in combination with other neuron groups because they would have had zero Φ on their own.

To measure the effect of the approximations described in Section 7.4.4, these group analyses were also run with five bipartitions per level and using only equal bipartitions. However, only the values with the least approximation were used to generate the XML descriptions in Section 7.9. The results are presented in Table A3.12 and included as XML files in the Supporting Materials. These group analysis results are not complexes because it has not been shown that they are not included within a subset of higher Φ. To make this distinction clear they are referred to as *clusters* in this thesis.

	Neuron Group(s)	Size	Φ	Parameters	Analysis Time
1a	Inhibition	25	77.3	All bipartition levels, 50 bipartitions per level	8 seconds
1b			77.3	Equal bipartitions, 50 bipartitions per level	8 seconds
1c			77.3	All bipartition levels, 5 bipartitions per level	7 seconds
2a	Emotion	25	79.9	All bipartition levels, 50 bipartitions per level	8 seconds
2b			79.9	Equal bipartitions, 50 bipartitions per level	7 seconds
2c			80.2	All bipartition levels, 5 bipartitions per level	7 seconds
3a	Emotion + Inhibition	50	7.1	All bipartition levels, 50 bipartitions per level	17 seconds
3b			7.1	Equal bipartitions, 50 bipartitions per level	7 seconds
3c			7.1	All bipartition levels, 5 bipartitions per level	8 seconds
4a	Inhibition + Motor Output	700	8.4	All bipartition levels, 50 bipartitions per level	3 days
4b			8.4	Equal bipartitions, 50 bipartitions per level	9 minutes
4c			8.4	All bipartition levels, 5 bipartitions per level	6 hours
5a	Motor Cortex	400	17.9	All bipartition levels, 50 bipartitions per level	12 hours
5b			17.9	Equal bipartitions, 50 bipartitions per level	3 minutes
5c			17.9	All bipartition levels, 5 bipartitions per level	1 hour
6a	Motor Cortex + Motor Integration	425	58.7	All bipartition levels, 50 bipartitions per level	16 hours
6b			80.5	Equal bipartitions, 50 bipartitions per level	3.5 minutes
6c			58.7	All bipartition levels, 5 bipartitions per level	1.3 hours
7a	Motor Integration + Eye Pan + Eye Tilt	35	31.8	All bipartition levels, 50 bipartitions per level	8 seconds
7b			36.2	Equal bipartitions, 50 bipartitions per level	7 seconds
7c			31.8	All bipartition levels, 5 bipartitions per level	7 seconds
8a	Motor Cortex + Motor Integration + Eye Pan + Eye Tilt	435	58.7	All bipartition levels, 50 bipartitions per level	16.5 hours
8b			80.7	Equal bipartitions, 50 bipartitions per level	4 minutes
8c			58.7	All bipartition levels, 5 bipartitions per level	1.3 hours
9a	Motor Integration + Eye Pan + Eye Tilt + Motor Output + Inhibition	735	46.8	All bipartition levels, 50 bipartitions per level	7 days
9b			46.8	Equal bipartitions, 50 bipartitions per level	22 minutes
9c			46.8	All bipartition levels, 5 bipartitions per level	13.5 hours

Table A3.12. Neuron group(s) analysis results. The 'b' analyses use equal bipartitions, the 'c' analyses use only 5 bipartitions per level. Only the more accurate 'a' values were used to generate the XML description in Section 7.9.