# Supplementary Information

## Connectome-derived structural support identifies a compact scaffold for robust embodied control in BIOSEED

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**Supplementary Table S1 | Environmental and sensorimotor shift evidence used in the BIOSEED analysis.**

**a, Agent14B aggregate environmental-shift replication.**

| Variant | n | Agent9_v2 score mean | Score SD | Foraging score mean | Survival steps mean | Food eaten mean | Wrong-side ratio | Toxin hits mean |
|---|---|---|---|---|---|---|---|---|
| TRUE | 1000 | 29.835 | 81.200 | 37.115 | 950.706 | 1.599 | 0.2802 | 4.390 |
| Density-matched rewired | 1000 | -0.126 | 55.272 | 20.923 | 715.305 | 0.554 | 0.4042 | 0.000 |
| Same-support weight shuffle | 1000 | 14.187 | 65.415 | 28.580 | 771.132 | 0.940 | 0.3624 | 1.190 |
| Same-support random sign/magnitude | 1000 | 6.794 | 58.157 | 7.721 | 735.033 | 0.692 | 0.1970 | 3.318 |
| No-connectome output | 1000 | 12.866 | 39.765 | 4.972 | 672.837 | 0.411 | 0.0231 | 0.906 |

*Panel a reports the aggregate Agent14B summary across its implemented environmental-shift block. It preserves the corrected density-matched rewiring result used in the manuscript's structural-control narrative. Source: Table_4_AGENT14B_real_shift_environment_summary.csv.*

**b, Agent17D held-out transfer/stress environments for the top-in 10% scaffold versus intact TRUE support.**

| Environment | Top-in 10% score mean | TRUE score mean | Top-in − TRUE | Fraction of TRUE | Top-in > TRUE |
|---|---|---|---|---|---|
| Food dropout | 132.329 | 123.231 | +9.099 | 1.0738 | Yes |
| High toxin | 165.831 | 144.722 | +21.109 | 1.1459 | Yes |
| Motor noise | 131.287 | 127.831 | +3.455 | 1.0270 | Yes |
| Moving toxin | 150.522 | 139.441 | +11.081 | 1.0795 | Yes |
| Scarce food | 131.877 | 116.459 | +15.418 | 1.1324 | Yes |
| Sensory noise | 142.065 | 132.211 | +9.854 | 1.0745 | Yes |

*Panel b reports the six disjoint held-out transfer/stress environments used in Agent17D. The six top-in 10% and TRUE means, deltas and fractions match the corresponding rows in AGENT17D_summary_by_environment.csv. Sources: Table_R3_agent17D_transfer_environment_top_in_10_vs_true.csv and AGENT17D_summary_by_environment.csv.*

**Provenance and interpretation note.**

Panels a and b are distinct experimental blocks and are not pooled. Agent14B provides the corrected aggregate environmental-shift replication; Agent17D provides the six held-out transfer/stress environments, including motor-noise and sensory-noise conditions. The supplementary presentation preserves this distinction so that the source of each manuscript claim remains auditable.

**Supplementary Table S2 | Full recurrent learned-controller sweep used for Fig. 3 and the competitive-control analysis.**

| Controller | Hidden size | Generations | Screen score mean | Foraging score mean | Food eaten mean | Δ eaten vs BIOSEED | Wrong-side ratio | Toxin hits mean | Survival steps mean | Toxin avoidance ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| BIOSEED baseline (frozen connectome) | — | — | 81.174 | 97.236 | 2.708 | 0.000 | 0.0000 | 0.000 | 798.383 | 0.9997 |
| GRU | 4 | 4 | 80.998 | 108.834 | 3.625 | 0.917 | 0.0398 | 6.333 | 783.933 | 0.9651 |
| GRU | 4 | 16 | 95.048 | 122.630 | 3.767 | 1.058 | 0.0099 | 2.158 | 798.425 | 0.9903 |
| GRU | 4 | 64 | 95.741 | 121.859 | 3.758 | 1.050 | 0.0128 | 1.608 | 798.825 | 0.9893 |
| GRU | 8 | 4 | 88.220 | 106.706 | 3.092 | 0.383 | 0.0099 | 0.000 | 800.000 | 0.9992 |
| GRU | 8 | 16 | 85.975 | 105.892 | 3.192 | 0.483 | 0.1199 | 0.200 | 800.000 | 0.9988 |
| GRU | 8 | 64 | 85.975 | 105.892 | 3.192 | 0.483 | 0.1199 | 0.200 | 800.000 | 0.9988 |
| GRU | 16 | 4 | 106.642 | 136.926 | 4.292 | 1.583 | 0.0244 | 0.242 | 800.000 | 0.9980 |
| GRU | 16 | 16 | 106.642 | 136.926 | 4.292 | 1.583 | 0.0244 | 0.242 | 800.000 | 0.9980 |
| GRU | 16 | 64 | 106.642 | 136.926 | 4.292 | 1.583 | 0.0244 | 0.242 | 800.000 | 0.9980 |
| RNN | 4 | 4 | 111.178 | 143.144 | 5.467 | 2.758 | 0.0232 | 6.542 | 794.358 | 0.9739 |
| RNN | 4 | 16 | 111.178 | 143.144 | 5.467 | 2.758 | 0.0232 | 6.542 | 794.358 | 0.9739 |
| RNN | 4 | 64 | 111.178 | 143.144 | 5.467 | 2.758 | 0.0232 | 6.542 | 794.358 | 0.9739 |
| RNN | 8 | 4 | 81.998 | 101.605 | 3.017 | 0.308 | 0.0401 | 1.808 | 786.225 | 0.9882 |
| RNN | 8 | 16 | 117.942 | 151.246 | 5.308 | 2.600 | 0.0092 | 2.608 | 798.650 | 0.9893 |
| RNN | 8 | 64 | 115.996 | 143.492 | 5.008 | 2.300 | 0.0045 | 0.892 | 800.000 | 0.9935 |
| RNN | 16 | 4 | 69.041 | 79.673 | 1.883 | -0.825 | 0.0043 | 0.700 | 797.658 | 0.9973 |
| RNN | 16 | 16 | 72.184 | 89.330 | 2.208 | -0.500 | 0.0697 | 0.000 | 794.400 | 1.0000 |
| RNN | 16 | 64 | 72.184 | 89.330 | 2.208 | -0.500 | 0.0697 | 0.000 | 794.400 | 1.0000 |

*Values are means from the locked recurrent budget sweep. The BIOSEED baseline is repeated in the source CSV for each learned-controller configuration; it is shown once here for clarity. Rounding is for presentation only. Source: Table_V75_recurrent_budget_control_summary.csv.*

**Source files used (**available at the Zenodo repository: https://doi.org/10.5281/zenodo.21263275 )

- Table_V75_recurrent_budget_control_summary.csv — full RNN/GRU recurrent budget sweep and repeated BIOSEED baseline.
- Table_4_AGENT14B_real_shift_environment_summary.csv — aggregate Agent14B environmental-shift replication by structural variant.
- Table_R3_agent17D_transfer_environment_top_in_10_vs_true.csv — concise six-environment top-in 10% versus TRUE transfer summary.
- AGENT17D_summary_by_environment.csv — full per-environment Agent17D summary used to cross-check every value in Panel b.