
Disentanglement Beyond Static vs. Dynamic: A Benchmark and Evaluation Framework for Multi-Factor Sequential Representations

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3D-Shapes Results

Table 1: **M-Swap** on the **3D-Shapes** dataset for **Sparse-AE**.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	$0.81 \pm 3e-03$	$0.15 \pm 3e-03$	$0.13 \pm 2e-03$	$0.29 \pm 4e-03$	$0.20 \pm 3e-03$	$0.37 \pm 5e-03$
	Wall hue	$0.13 \pm 2e-03$	$0.45 \pm 4e-03$	$0.13 \pm 3e-03$	$0.28 \pm 4e-03$	$0.19 \pm 3e-03$	$0.36 \pm 6e-03$
	Object hue	$0.13 \pm 3e-03$	$0.13 \pm 2e-03$	$0.59 \pm 3e-03$	$0.31 \pm 6e-03$	$0.19 \pm 3e-03$	$0.38 \pm 5e-03$
	Shape	$0.13 \pm 2e-03$	$0.13 \pm 2e-03$	$0.13 \pm 3e-03$	$0.49 \pm 3e-03$	$0.19 \pm 3e-03$	$0.37 \pm 5e-03$
	Scale dynamic	$0.13 \pm 1e-03$	$0.13 \pm 2e-03$	$0.13 \pm 2e-03$	$0.28 \pm 4e-03$	$0.66 \pm 2e-03$	$0.36 \pm 3e-03$
	Orientation dynamic	$0.13 \pm 2e-03$	$0.13 \pm 2e-03$	$0.13 \pm 3e-03$	$0.39 \pm 4e-03$	$0.24 \pm 5e-03$	$0.69 \pm 1e-03$
Two-factor	Dynamic	$0.13 \pm 3e-03$	$0.13 \pm 4e-03$	$0.13 \pm 4e-03$	$0.40 \pm 5e-03$	$0.87 \pm 4e-03$	$0.64 \pm 2e-03$
	Static	$0.91 \pm 1e-03$	$0.99 \pm 6e-04$	$0.92 \pm 2e-03$	$0.61 \pm 4e-03$	$0.23 \pm 4e-03$	$0.41 \pm 5e-03$

Table 2: **M-Swap** on the **3D-Shapes** dataset for **VAE**.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	$0.33 \pm 4e-03$	$0.13 \pm 2e-03$	$0.13 \pm 3e-03$	$0.28 \pm 5e-03$	$0.20 \pm 2e-03$	$0.39 \pm 4e-03$
	Wall hue	$0.16 \pm 4e-03$	$0.98 \pm 1e-03$	$0.13 \pm 3e-03$	$0.28 \pm 5e-03$	$0.20 \pm 2e-03$	$0.40 \pm 4e-03$
	Object hue	$0.13 \pm 4e-03$	$0.13 \pm 2e-03$	$0.93 \pm 2e-03$	$0.28 \pm 5e-03$	$0.20 \pm 2e-03$	$0.35 \pm 5e-03$
	Shape	$0.13 \pm 4e-03$	$0.13 \pm 2e-03$	$0.13 \pm 3e-03$	$0.93 \pm 2e-03$	$0.20 \pm 2e-03$	$0.35 \pm 4e-03$
	Scale dynamic	$0.13 \pm 4e-03$	$0.13 \pm 2e-03$	$0.13 \pm 3e-03$	$0.28 \pm 5e-03$	$0.88 \pm 3e-03$	$0.35 \pm 4e-03$
	Orientation dynamic	$0.13 \pm 4e-03$	$0.13 \pm 2e-03$	$0.13 \pm 3e-03$	$0.27 \pm 5e-03$	$0.20 \pm 2e-03$	$0.61 \pm 5e-03$
Two-factor	Dynamic	$0.13 \pm 4e-03$	$0.13 \pm 1e-03$	$0.13 \pm 4e-03$	$0.27 \pm 5e-03$	$0.89 \pm 1e-03$	$0.62 \pm 5e-03$
	Static	$1.00 \pm 3e-04$	$1.00 \pm 3e-04$	$1.00 \pm 2e-04$	$0.99 \pm 7e-04$	$0.22 \pm 3e-03$	$0.51 \pm 3e-03$

*Equal contribution

Table 3: **M-Swap** on the **3D-Shapes** dataset for β -VAE.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	$0.35 \pm 3e-03$	$0.14 \pm 4e-03$	$0.13 \pm 3e-03$	$0.27 \pm 6e-03$	$0.19 \pm 4e-03$	$0.36 \pm 4e-03$
	Wall hue	$0.14 \pm 3e-03$	$0.29 \pm 4e-03$	$0.13 \pm 4e-03$	$0.29 \pm 5e-03$	$0.19 \pm 4e-03$	$0.36 \pm 5e-03$
	Object hue	$0.13 \pm 3e-03$	$0.13 \pm 4e-03$	$0.55 \pm 3e-03$	$0.27 \pm 6e-03$	$0.19 \pm 4e-03$	$0.35 \pm 4e-03$
	Shape	$0.13 \pm 2e-03$	$0.14 \pm 5e-03$	$0.13 \pm 2e-03$	$0.43 \pm 2e-03$	$0.19 \pm 4e-03$	$0.37 \pm 5e-03$
	Scale dynamic	$0.13 \pm 3e-03$	$0.13 \pm 3e-03$	$0.13 \pm 2e-03$	$0.28 \pm 5e-03$	$0.38 \pm 5e-03$	$0.36 \pm 3e-03$
	Orientation dynamic	$0.13 \pm 3e-03$	$0.13 \pm 3e-03$	$0.13 \pm 2e-03$	$0.31 \pm 4e-03$	$0.29 \pm 4e-03$	$0.79 \pm 2e-03$
Two-factor	Dynamic	$0.13 \pm 3e-03$	$0.13 \pm 2e-03$	$0.13 \pm 2e-03$	$0.32 \pm 9e-03$	$0.67 \pm 3e-03$	$0.82 \pm 2e-03$
	Static	$0.98 \pm 1e-03$	$1.00 \pm 5e-04$	$0.97 \pm 8e-04$	$0.65 \pm 1e-03$	$0.20 \pm 4e-03$	$0.38 \pm 4e-03$

Table 4: **M-Swap** on the **3D-Shapes** dataset for MGP-VAE.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	$0.50 \pm 3e-03$	$0.12 \pm 3e-03$	$0.13 \pm 3e-03$	$0.27 \pm 3e-03$	$0.19 \pm 3e-03$	$0.35 \pm 5e-03$
	Wall hue	$0.13 \pm 2e-03$	$0.76 \pm 2e-03$	$0.17 \pm 4e-03$	$0.27 \pm 4e-03$	$0.19 \pm 3e-03$	$0.35 \pm 6e-03$
	Object hue	$0.20 \pm 2e-03$	$0.12 \pm 3e-03$	$0.24 \pm 4e-03$	$0.27 \pm 2e-03$	$0.19 \pm 3e-03$	$0.35 \pm 6e-03$
	Shape	$0.13 \pm 2e-03$	$0.12 \pm 3e-03$	$0.13 \pm 3e-03$	$0.35 \pm 7e-03$	$0.19 \pm 3e-03$	$0.35 \pm 6e-03$
	Scale dynamic	$0.18 \pm 3e-03$	$0.17 \pm 3e-03$	$0.21 \pm 4e-03$	$0.27 \pm 3e-03$	$1.00 \pm 3e-04$	$0.67 \pm 3e-03$
	Orientation dynamic	$0.13 \pm 2e-03$	$0.12 \pm 3e-03$	$0.17 \pm 3e-03$	$0.36 \pm 6e-03$	$0.19 \pm 3e-03$	$0.57 \pm 3e-03$
Two-factor	Dynamic	$0.18 \pm 2e-03$	$0.17 \pm 3e-03$	$0.30 \pm 5e-03$	$0.36 \pm 6e-03$	$1.00 \pm 4e-04$	$1.00 \pm 3e-04$
	Static	$0.74 \pm 2e-03$	$0.78 \pm 3e-03$	$0.45 \pm 4e-03$	$0.78 \pm 3e-03$	$0.19 \pm 5e-03$	$0.35 \pm 7e-03$

Table 5: **M-Swap** on the **3D-Shapes** dataset for SKD.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	$0.42 \pm 4e-03$	$0.23 \pm 4e-03$	$0.12 \pm 2e-03$	$0.26 \pm 5e-03$	$0.17 \pm 4e-03$	$0.33 \pm 8e-03$
	Wall hue	$0.13 \pm 3e-03$	$0.19 \pm 4e-03$	$0.16 \pm 4e-03$	$0.26 \pm 4e-03$	$0.17 \pm 4e-03$	$0.33 \pm 9e-03$
	Object hue	$0.13 \pm 3e-03$	$0.13 \pm 2e-03$	$0.28 \pm 9e-04$	$0.26 \pm 5e-03$	$0.17 \pm 4e-03$	$0.33 \pm 6e-03$
	Shape	$0.10 \pm 3e-03$	$0.10 \pm 2e-03$	$0.10 \pm 2e-03$	$0.81 \pm 3e-03$	$0.18 \pm 3e-03$	$0.33 \pm 8e-03$
	Scale dynamic	$0.10 \pm 3e-03$	$0.10 \pm 2e-03$	$0.10 \pm 2e-03$	$0.28 \pm 5e-03$	$0.95 \pm 3e-03$	$0.33 \pm 7e-03$
	Orientation dynamic	$0.10 \pm 3e-03$	$0.10 \pm 2e-03$	$0.10 \pm 2e-03$	$0.25 \pm 5e-03$	$0.17 \pm 4e-03$	$0.98 \pm 6e-03$
Two-factor	Dynamic	$0.10 \pm 4e-03$	$0.10 \pm 4e-03$	$0.10 \pm 4e-03$	$0.29 \pm 5e-03$	$0.95 \pm 1e-03$	$0.99 \pm 2e-03$
	Static	$1.00 \pm 4e-04$	$0.99 \pm 2e-03$	$0.98 \pm 2e-03$	$0.90 \pm 1e-03$	$0.18 \pm 5e-03$	$0.34 \pm 6e-03$

Table 6: **M-Swap** on the **3D-Shapes** dataset for SSM-SKD.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	$0.95 \pm 1e-03$	$0.10 \pm 2e-03$	$0.10 \pm 2e-03$	$0.25 \pm 5e-03$	$0.17 \pm 3e-03$	$0.33 \pm 6e-03$
	Wall hue	$0.10 \pm 1e-03$	$0.88 \pm 2e-03$	$0.10 \pm 2e-03$	$0.25 \pm 5e-03$	$0.17 \pm 3e-03$	$0.33 \pm 6e-03$
	Object hue	$0.10 \pm 1e-03$	$0.10 \pm 2e-03$	$0.76 \pm 4e-03$	$0.28 \pm 5e-03$	$0.17 \pm 3e-03$	$0.34 \pm 6e-03$
	Shape	$0.10 \pm 1e-03$	$0.10 \pm 3e-03$	$0.11 \pm 2e-03$	$0.72 \pm 5e-03$	$0.17 \pm 3e-03$	$0.34 \pm 6e-03$
	Scale dynamic	$0.10 \pm 1e-03$	$0.10 \pm 2e-03$	$0.10 \pm 2e-03$	$0.27 \pm 4e-03$	$1.00 \pm 1e-04$	$0.33 \pm 6e-03$
	Orientation dynamic	$0.10 \pm 1e-03$	$0.11 \pm 2e-03$	$0.10 \pm 2e-03$	$0.25 \pm 4e-03$	$0.17 \pm 3e-03$	$0.94 \pm 3e-03$
Two-factor	Dynamic	$0.10 \pm 1e-03$	$0.11 \pm 3e-03$	$0.11 \pm 2e-03$	$0.29 \pm 5e-03$	$1.00 \pm 5e-05$	$0.95 \pm 1e-03$
	Static	$0.99 \pm 1e-03$	$0.94 \pm 8e-04$	$0.96 \pm 2e-03$	$0.94 \pm 2e-03$	$0.17 \pm 5e-03$	$0.35 \pm 3e-03$

Table 7: **M-GSample** on the **3D-Shapes** dataset for Sparse-AE.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	$0.29 \pm 4e-03$	$0.11 \pm 2e-03$	$0.10 \pm 2e-03$	$0.26 \pm 4e-03$	$0.18 \pm 2e-03$	$0.33 \pm 6e-03$
	Wall hue	$0.10 \pm 4e-03$	$0.20 \pm 3e-03$	$0.10 \pm 3e-03$	$0.26 \pm 1e-03$	$0.17 \pm 2e-03$	$0.33 \pm 6e-03$
	Object hue	$0.10 \pm 2e-03$	$0.10 \pm 7e-04$	$0.23 \pm 2e-03$	$0.26 \pm 3e-03$	$0.17 \pm 3e-03$	$0.34 \pm 6e-03$
	Shape	$0.10 \pm 4e-03$	$0.10 \pm 2e-03$	$0.10 \pm 2e-03$	$0.30 \pm 4e-03$	$0.17 \pm 5e-03$	$0.34 \pm 4e-03$
	Scale dynamic	$0.10 \pm 4e-03$	$0.10 \pm 3e-03$	$0.10 \pm 3e-03$	$0.26 \pm 4e-03$	$0.28 \pm 3e-03$	$0.33 \pm 5e-03$
	Orientation dynamic	$0.10 \pm 4e-03$	$0.10 \pm 3e-03$	$0.10 \pm 2e-03$	$0.29 \pm 3e-03$	$0.18 \pm 3e-03$	$0.41 \pm 3e-03$
Two-factor	Dynamic	$0.10 \pm 4e-03$	$0.10 \pm 2e-03$	$0.10 \pm 1e-03$	$0.29 \pm 5e-03$	$0.37 \pm 7e-03$	$0.42 \pm 5e-03$
	Static	$0.59 \pm 5e-03$	$0.80 \pm 2e-03$	$0.50 \pm 4e-03$	$0.33 \pm 5e-03$	$0.19 \pm 4e-03$	$0.34 \pm 6e-03$

Table 8: **M-GSample** on the **3D-Shapes** dataset for **VAE**.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	0.32 \pm 4e-03	0.10 \pm 4e-03	0.10 \pm 5e-03	0.25 \pm 4e-03	0.17 \pm 3e-03	0.37 \pm 4e-03
	Wall hue	0.15 \pm 1e-03	0.97 \pm 2e-03	0.10 \pm 3e-03	0.26 \pm 2e-03	0.20 \pm 4e-03	0.39 \pm 4e-03
	Object hue	0.10 \pm 3e-03	0.10 \pm 3e-03	0.95 \pm 2e-03	0.26 \pm 3e-03	0.17 \pm 3e-03	0.34 \pm 7e-03
	Shape	0.10 \pm 4e-03	0.10 \pm 2e-03	0.10 \pm 3e-03	0.85 \pm 6e-03	0.18 \pm 3e-03	0.34 \pm 7e-03
	Scale dynamic	0.10 \pm 3e-03	0.10 \pm 3e-03	0.10 \pm 4e-03	0.26 \pm 2e-03	0.80 \pm 3e-03	0.34 \pm 9e-03
	Orientation dynamic	0.10 \pm 3e-03	0.10 \pm 2e-03	0.10 \pm 5e-03	0.25 \pm 3e-03	0.18 \pm 4e-03	0.52 \pm 4e-03
Two-factor	Dynamic	0.10 \pm 2e-03	0.10 \pm 3e-03	0.10 \pm 1e-03	0.25 \pm 2e-03	0.83 \pm 4e-03	0.52 \pm 5e-03
	Static	1.00 \pm 3e-04	1.00 \pm 3e-04	1.00 \pm 2e-04	0.99 \pm 7e-04	0.23 \pm 9e-04	0.48 \pm 5e-03

Table 9: **M-GSample** on the **3D-Shapes** dataset for β -VAE.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	0.36 \pm 2e-03	0.11 \pm 3e-03	0.10 \pm 2e-03	0.25 \pm 2e-03	0.17 \pm 3e-03	0.34 \pm 9e-03
	Wall hue	0.11 \pm 2e-03	0.29 \pm 4e-03	0.10 \pm 4e-03	0.27 \pm 5e-03	0.17 \pm 3e-03	0.35 \pm 5e-03
	Object hue	0.10 \pm 2e-03	0.10 \pm 2e-03	0.58 \pm 3e-03	0.25 \pm 3e-03	0.17 \pm 2e-03	0.34 \pm 8e-03
	Shape	0.10 \pm 2e-03	0.11 \pm 3e-03	0.10 \pm 3e-03	0.44 \pm 3e-03	0.17 \pm 2e-03	0.36 \pm 6e-03
	Scale dynamic	0.10 \pm 3e-03	0.10 \pm 2e-03	0.10 \pm 1e-03	0.26 \pm 2e-03	0.36 \pm 6e-03	0.34 \pm 7e-03
	Orientation dynamic	0.10 \pm 4e-03	0.10 \pm 2e-03	0.10 \pm 2e-03	0.28 \pm 2e-03	0.27 \pm 4e-03	0.78 \pm 3e-03
Two-factor	Dynamic	0.10 \pm 3e-03	0.10 \pm 7e-04	0.10 \pm 3e-03	0.30 \pm 3e-03	0.64 \pm 5e-03	0.80 \pm 2e-03
	Static	0.99 \pm 9e-04	1.00 \pm 3e-04	0.98 \pm 1e-03	0.65 \pm 2e-03	0.18 \pm 3e-03	0.37 \pm 4e-03

Table 10: **M-GSample** on the **3D-Shapes** dataset for **MGP-VAE**.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	0.15 \pm 5e-03	0.10 \pm 1e-03	0.10 \pm 2e-03	0.25 \pm 4e-03	0.17 \pm 4e-03	0.34 \pm 5e-03
	Wall hue	0.10 \pm 3e-03	0.27 \pm 4e-03	0.11 \pm 2e-03	0.25 \pm 6e-03	0.17 \pm 4e-03	0.34 \pm 3e-03
	Object hue	0.11 \pm 3e-03	0.10 \pm 3e-03	0.11 \pm 1e-03	0.25 \pm 2e-03	0.17 \pm 5e-03	0.33 \pm 3e-03
	Shape	0.10 \pm 4e-03	0.10 \pm 2e-03	0.10 \pm 2e-03	0.26 \pm 3e-03	0.17 \pm 4e-03	0.33 \pm 4e-03
	Scale dynamic	0.10 \pm 3e-03	0.10 \pm 4e-03	0.11 \pm 3e-03	0.25 \pm 4e-03	0.32 \pm 4e-03	0.40 \pm 4e-03
	Orientation dynamic	0.10 \pm 3e-03	0.10 \pm 2e-03	0.10 \pm 3e-03	0.26 \pm 3e-03	0.17 \pm 4e-03	0.37 \pm 5e-03
Two-factor	Dynamic	0.10 \pm 1e-03	0.11 \pm 2e-03	0.12 \pm 2e-03	0.27 \pm 3e-03	0.35 \pm 4e-03	0.49 \pm 6e-03
	Static	0.40 \pm 1e-03	0.49 \pm 3e-03	0.29 \pm 5e-03	0.55 \pm 3e-03	0.17 \pm 3e-03	0.33 \pm 2e-03

Table 11: **M-GSample** on the **3D-Shapes** dataset for **SKD**.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	0.45 \pm 5e-03	0.24 \pm 3e-03	0.12 \pm 2e-03	0.26 \pm 5e-03	0.17 \pm 5e-03	0.33 \pm 4e-03
	Wall hue	0.14 \pm 2e-03	0.21 \pm 2e-03	0.16 \pm 3e-03	0.27 \pm 2e-03	0.17 \pm 3e-03	0.34 \pm 3e-03
	Object hue	0.13 \pm 5e-03	0.13 \pm 2e-03	0.31 \pm 3e-03	0.27 \pm 5e-03	0.17 \pm 4e-03	0.34 \pm 5e-03
	Shape	0.10 \pm 4e-03	0.10 \pm 2e-03	0.10 \pm 3e-03	0.87 \pm 1e-03	0.20 \pm 3e-03	0.33 \pm 4e-03
	Scale dynamic	0.10 \pm 4e-03	0.10 \pm 3e-03	0.10 \pm 2e-03	0.31 \pm 5e-03	0.97 \pm 1e-03	0.35 \pm 5e-03
	Orientation dynamic	0.10 \pm 4e-03	0.11 \pm 3e-03	0.10 \pm 2e-03	0.26 \pm 3e-03	0.18 \pm 4e-03	0.98 \pm 2e-03
Two-factor	Dynamic	0.11 \pm 3e-03	0.11 \pm 2e-03	0.11 \pm 3e-03	0.33 \pm 3e-03	0.97 \pm 1e-03	0.99 \pm 4e-03
	Static	1.00 \pm 3e-04	0.99 \pm 4e-04	0.99 \pm 1e-03	0.92 \pm 4e-03	0.21 \pm 4e-03	0.35 \pm 5e-03

Table 12: **M-GSample** on the **3D-Shapes** dataset for **SSM-SKD**.

Category	Type	Floor hue	Wall hue	Object hue	Shape	Scale dynamic	Orientation dynamic
Uni-factor	Floor hue	0.98 \pm 8e-04	0.10 \pm 3e-03	0.10 \pm 2e-03	0.25 \pm 4e-03	0.17 \pm 5e-03	0.34 \pm 3e-03
	Wall hue	0.10 \pm 2e-03	0.92 \pm 4e-03	0.10 \pm 3e-03	0.25 \pm 4e-03	0.17 \pm 3e-03	0.33 \pm 3e-03
	Object hue	0.11 \pm 3e-03	0.10 \pm 3e-03	0.85 \pm 4e-03	0.33 \pm 4e-03	0.17 \pm 3e-03	0.35 \pm 5e-03
	Shape	0.11 \pm 2e-03	0.12 \pm 3e-03	0.14 \pm 4e-03	0.81 \pm 3e-03	0.17 \pm 3e-03	0.34 \pm 4e-03
	Scale dynamic	0.10 \pm 3e-03	0.11 \pm 2e-03	0.11 \pm 4e-03	0.33 \pm 3e-03	1.00 \pm 1e-04	0.35 \pm 5e-03
	Orientation dynamic	0.11 \pm 3e-03	0.14 \pm 3e-03	0.11 \pm 4e-03	0.27 \pm 3e-03	0.17 \pm 4e-03	0.96 \pm 1e-03
Two-factor	Dynamic	0.12 \pm 3e-03	0.15 \pm 2e-03	0.13 \pm 2e-03	0.36 \pm 4e-03	1.00 \pm 1e-04	0.96 \pm 2e-03
	Static	1.00 \pm 6e-04	0.97 \pm 2e-03	0.97 \pm 8e-04	0.96 \pm 1e-03	0.17 \pm 1e-03	0.39 \pm 1e-03

Table 13: **DCI** on the **3D-Shapes** dataset for **Sparse-AE**.

None	DCI-M \uparrow	DCI-C \uparrow	DCI-E \uparrow
Floor hue	$0.90 \pm 3\text{e-}03$	$0.95 \pm 1\text{e-}03$	$0.94 \pm 3\text{e-}03$
Wall hue	$0.96 \pm 2\text{e-}03$	$0.98 \pm 3\text{e-}04$	$0.98 \pm 2\text{e-}03$
Object hue	$0.78 \pm 3\text{e-}03$	$0.92 \pm 1\text{e-}03$	$0.86 \pm 6\text{e-}03$
Shape	$0.78 \pm 7\text{e-}03$	$0.84 \pm 8\text{e-}04$	$1.00 \pm 5\text{e-}04$
Scale dynamic	$0.72 \pm 3\text{e-}03$	$0.90 \pm 2\text{e-}03$	$1.00 \pm 0\text{e+}00$
Orientation dynamic	$0.46 \pm 1\text{e-}03$	$0.94 \pm 7\text{e-}04$	$0.99 \pm 1\text{e-}03$

Table 14: **DCI** on the **3D-Shapes** dataset for **VAE**.

None	DCI-M \uparrow	DCI-C \uparrow	DCI-E \uparrow
Floor hue	$0.90 \pm 7\text{e-}03$	$0.97 \pm 1\text{e-}03$	$0.98 \pm 4\text{e-}03$
Wall hue	$0.86 \pm 5\text{e-}03$	$0.98 \pm 1\text{e-}03$	$0.97 \pm 4\text{e-}03$
Object hue	$0.97 \pm 3\text{e-}03$	$0.99 \pm 2\text{e-}03$	$1.00 \pm 7\text{e-}04$
Shape	$0.93 \pm 4\text{e-}03$	$0.99 \pm 1\text{e-}03$	$1.00 \pm 3\text{e-}04$
Scale dynamic	$0.78 \pm 4\text{e-}03$	$0.98 \pm 1\text{e-}03$	$0.99 \pm 2\text{e-}03$
Orientation dynamic	$0.97 \pm 4\text{e-}03$	$0.89 \pm 1\text{e-}03$	$0.99 \pm 3\text{e-}03$

Table 15: **DCI** on the **3D-Shapes** dataset for β -**VAE**.

None	DCI-M \uparrow	DCI-C \uparrow	DCI-E \uparrow
Floor hue	$0.60 \pm 3\text{e-}03$	$0.88 \pm 1\text{e-}03$	$0.93 \pm 3\text{e-}03$
Wall hue	$0.30 \pm 2\text{e-}03$	$0.83 \pm 9\text{e-}04$	$0.77 \pm 7\text{e-}03$
Object hue	$0.85 \pm 3\text{e-}03$	$0.92 \pm 1\text{e-}03$	$0.94 \pm 4\text{e-}03$
Shape	$0.44 \pm 3\text{e-}03$	$0.77 \pm 7\text{e-}04$	$0.96 \pm 5\text{e-}03$
Scale dynamic	$0.70 \pm 7\text{e-}03$	$0.83 \pm 2\text{e-}03$	$0.95 \pm 2\text{e-}03$
Orientation dynamic	$0.48 \pm 4\text{e-}03$	$0.94 \pm 2\text{e-}03$	$0.99 \pm 2\text{e-}03$

Table 16: **DCI** on the **3D-Shapes** dataset for **MGP-VAE**.

None	DCI-M \uparrow	DCI-C \uparrow	DCI-E \uparrow
Floor hue	$0.43 \pm 1e-02$	$0.62 \pm 2e-03$	$0.50 \pm 1e-02$
Wall hue	$0.18 \pm 6e-03$	$0.59 \pm 8e-03$	$0.31 \pm 7e-03$
Object hue	$0.14 \pm 5e-03$	$0.39 \pm 2e-03$	$0.52 \pm 9e-03$
Shape	$0.18 \pm 1e-02$	$0.38 \pm 5e-03$	$0.42 \pm 1e-02$
Scale dynamic	$0.22 \pm 7e-03$	$0.62 \pm 4e-03$	$0.41 \pm 1e-02$
Orientation dynamic	$0.33 \pm 4e-03$	$0.50 \pm 6e-03$	$0.52 \pm 8e-03$

Table 17: **DCI** on the **3D-Shapes** dataset for **SKD**.

None	DCI-M \uparrow	DCI-C \uparrow	DCI-E \uparrow
Floor hue	$0.21 \pm 5e-03$	$0.68 \pm 4e-03$	$0.58 \pm 1e-03$
Wall hue	$0.10 \pm 4e-03$	$0.59 \pm 5e-03$	$0.51 \pm 7e-04$
Object hue	$0.11 \pm 8e-05$	$0.61 \pm 4e-03$	$0.47 \pm 6e-04$
Shape	$0.49 \pm 7e-04$	$0.78 \pm 3e-04$	$0.81 \pm 0e+00$
Scale dynamic	$0.35 \pm 5e-02$	$0.55 \pm 2e-03$	$0.40 \pm 2e-04$
Orientation dynamic	$0.19 \pm 6e-03$	$0.58 \pm 7e-03$	$0.71 \pm 2e-04$

Table 18: **DCI** on the **3D-Shapes** dataset for **SSM-SKD**.

None	DCI-M \uparrow	DCI-C \uparrow	DCI-E \uparrow
Floor hue	$0.96 \pm 1e-03$	$0.99 \pm 3e-04$	$1.00 \pm 0e+00$
Wall hue	$0.94 \pm 3e-04$	$1.00 \pm 9e-05$	$1.00 \pm 0e+00$
Object hue	$0.87 \pm 1e-04$	$0.99 \pm 1e-04$	$1.00 \pm 0e+00$
Shape	$0.91 \pm 4e-04$	$0.91 \pm 3e-04$	$1.00 \pm 0e+00$
Scale dynamic	$0.94 \pm 8e-04$	$0.95 \pm 3e-04$	$0.98 \pm 5e-04$
Orientation dynamic	$0.92 \pm 9e-04$	$0.95 \pm 1e-04$	$1.00 \pm 0e+00$

Table 19: **Consistency** on the **3D-Shapes** dataset for **Sparse-AE**.

Category	Type	Shape	Object hue	Floor hue	Wall hue
C-Swap \uparrow	Shape	$0.49 \pm 5e-03$	$0.90 \pm 3e-03$	$1.00 \pm 2e-04$	$1.00 \pm 5e-05$
	Object hue	$0.85 \pm 2e-03$	$0.59 \pm 6e-03$	$0.83 \pm 2e-03$	$0.93 \pm 2e-03$
	Floor hue	$0.92 \pm 2e-03$	$0.66 \pm 5e-03$	$0.80 \pm 2e-03$	$0.46 \pm 3e-03$
	Wall hue	$0.98 \pm 1e-03$	$0.97 \pm 2e-03$	$0.99 \pm 9e-04$	$0.44 \pm 4e-03$
C-Sample \uparrow	Shape	$0.99 \pm 5e-04$	$0.97 \pm 7e-04$	$0.98 \pm 8e-04$	$0.99 \pm 6e-04$
	Object hue	$0.99 \pm 3e-04$	$0.99 \pm 5e-04$	$0.98 \pm 1e-03$	$0.99 \pm 7e-04$
	Floor hue	$0.99 \pm 4e-04$	$0.98 \pm 1e-03$	$0.99 \pm 4e-04$	$0.99 \pm 4e-04$
	Wall hue	$0.99 \pm 3e-04$	$0.97 \pm 7e-04$	$0.98 \pm 1e-03$	$0.99 \pm 5e-04$
GC-Sample \uparrow	Shape	$0.99 \pm 7e-04$	$0.98 \pm 8e-04$	$0.98 \pm 1e-03$	$0.99 \pm 4e-04$
	Object hue	$0.99 \pm 4e-04$	$0.99 \pm 7e-04$	$0.98 \pm 9e-04$	$0.99 \pm 3e-04$
	Floor hue	$0.99 \pm 5e-04$	$0.98 \pm 6e-04$	$0.99 \pm 9e-04$	$0.99 \pm 3e-04$
	Wall hue	$0.99 \pm 6e-04$	$0.98 \pm 2e-03$	$0.98 \pm 1e-03$	$0.99 \pm 5e-04$

Table 20: **Consistency** on the **3D-Shapes** dataset for **VAE**.

Category	Type	Object hue	Wall hue	Floor hue	Shape
C-Swap \uparrow	Object hue	$0.93 \pm 2e-03$	$1.00 \pm 3e-04$	$1.00 \pm 6e-04$	$1.00 \pm 4e-04$
	Wall hue	$1.00 \pm 4e-04$	$0.98 \pm 1e-03$	$0.35 \pm 3e-03$	$0.98 \pm 2e-03$
	Floor hue	$0.98 \pm 1e-03$	$0.98 \pm 1e-03$	$0.32 \pm 3e-03$	$1.00 \pm 4e-04$
	Shape	$0.99 \pm 5e-04$	$1.00 \pm 2e-04$	$1.00 \pm 1e-04$	$0.93 \pm 2e-03$
C-Sample \uparrow	Object hue	$1.00 \pm 2e-04$	$1.00 \pm 4e-04$	$0.99 \pm 4e-04$	$1.00 \pm 5e-04$
	Wall hue	$1.00 \pm 4e-04$	$1.00 \pm 1e-04$	$1.00 \pm 5e-04$	$1.00 \pm 3e-04$
	Floor hue	$0.99 \pm 4e-04$	$1.00 \pm 2e-04$	$1.00 \pm 2e-04$	$1.00 \pm 3e-04$
	Shape	$0.99 \pm 4e-04$	$1.00 \pm 5e-04$	$0.99 \pm 5e-04$	$1.00 \pm 1e-04$
GC-Sample \uparrow	Object hue	$1.00 \pm 1e-04$	$1.00 \pm 2e-04$	$0.99 \pm 4e-04$	$1.00 \pm 4e-04$
	Wall hue	$1.00 \pm 4e-04$	$1.00 \pm 9e-05$	$1.00 \pm 3e-04$	$1.00 \pm 1e-04$
	Floor hue	$0.99 \pm 5e-04$	$1.00 \pm 9e-05$	$1.00 \pm 8e-04$	$1.00 \pm 2e-04$
	Shape	$1.00 \pm 3e-04$	$1.00 \pm 4e-04$	$0.99 \pm 6e-04$	$1.00 \pm 2e-04$

Table 21: **Consistency** on the **3D-Shapes** dataset for β -VAE.

Category	Type	Wall hue	Floor hue	Shape	Object hue
C-Swap \uparrow	Wall hue	$0.29 \pm 3e-03$	$0.44 \pm 4e-03$	$0.52 \pm 2e-03$	$0.64 \pm 2e-03$
	Floor hue	$0.34 \pm 6e-03$	$0.35 \pm 6e-03$	$0.97 \pm 1e-03$	$0.75 \pm 4e-03$
	Shape	$0.47 \pm 8e-03$	$0.67 \pm 6e-03$	$0.43 \pm 1e-03$	$0.97 \pm 1e-03$
	Object hue	$0.78 \pm 5e-03$	$0.98 \pm 1e-03$	$0.95 \pm 2e-03$	$0.55 \pm 3e-03$
C-Sample \uparrow	Wall hue	$1.00 \pm 3e-04$	$1.00 \pm 1e-04$	$1.00 \pm 2e-04$	$1.00 \pm 2e-04$
	Floor hue	$1.00 \pm 3e-04$	$1.00 \pm 1e-04$	$1.00 \pm 2e-04$	$1.00 \pm 1e-04$
	Shape	$1.00 \pm 2e-04$	$1.00 \pm 3e-04$	$1.00 \pm 2e-04$	$1.00 \pm 2e-04$
	Object hue	$1.00 \pm 3e-04$	$1.00 \pm 5e-04$	$1.00 \pm 3e-04$	$1.00 \pm 2e-04$
GC-Sample \uparrow	Wall hue	$1.00 \pm 2e-04$	$1.00 \pm 5e-04$	$1.00 \pm 2e-04$	$1.00 \pm 4e-04$
	Floor hue	$1.00 \pm 2e-04$	$1.00 \pm 2e-04$	$1.00 \pm 3e-04$	$1.00 \pm 2e-04$
	Shape	$1.00 \pm 1e-04$	$1.00 \pm 2e-04$	$1.00 \pm 2e-04$	$1.00 \pm 2e-04$
	Object hue	$1.00 \pm 3e-04$	$1.00 \pm 3e-04$	$1.00 \pm 2e-04$	$1.00 \pm 3e-04$

Table 22: **Consistency** on the **3D-Shapes** dataset for **MGP-VAE**.

Category	Type	Object hue	Shape	Wall hue	Floor hue
C-Swap \uparrow	Object hue	$0.25 \pm 4e-03$	$0.57 \pm 3e-03$	$1.00 \pm 3e-04$	$0.67 \pm 4e-03$
	Shape	$0.99 \pm 1e-03$	$0.35 \pm 5e-03$	$1.00 \pm 4e-04$	$1.00 \pm 3e-04$
	Wall hue	$0.83 \pm 3e-03$	$0.84 \pm 2e-03$	$0.76 \pm 3e-03$	$1.00 \pm 5e-04$
	Floor hue	$0.99 \pm 7e-04$	$0.99 \pm 4e-04$	$1.00 \pm 4e-04$	$0.50 \pm 5e-03$
C-Sample \uparrow	Object hue	$0.84 \pm 1e-03$	$0.82 \pm 1e-03$	$0.73 \pm 3e-03$	$0.82 \pm 1e-03$
	Shape	$0.84 \pm 4e-03$	$0.82 \pm 1e-03$	$0.72 \pm 4e-03$	$0.81 \pm 3e-03$
	Wall hue	$0.87 \pm 2e-03$	$0.84 \pm 2e-03$	$0.76 \pm 2e-03$	$0.85 \pm 2e-03$
	Floor hue	$0.84 \pm 2e-03$	$0.82 \pm 2e-03$	$0.71 \pm 2e-03$	$0.82 \pm 2e-03$
GC-Sample \uparrow	Object hue	$0.83 \pm 2e-03$	$0.82 \pm 1e-03$	$0.70 \pm 4e-03$	$0.80 \pm 3e-03$
	Shape	$0.82 \pm 4e-03$	$0.82 \pm 2e-03$	$0.68 \pm 3e-03$	$0.79 \pm 2e-03$
	Wall hue	$0.85 \pm 1e-03$	$0.84 \pm 3e-03$	$0.73 \pm 2e-03$	$0.83 \pm 2e-03$
	Floor hue	$0.82 \pm 3e-03$	$0.82 \pm 2e-03$	$0.68 \pm 8e-04$	$0.80 \pm 2e-03$

Table 23: **Consistency** on the **3D-Shapes** dataset for **SKD**.

Category	Type	Object hue	Shape	Wall hue	Floor hue
C-Swap \uparrow	Object hue	$0.28 \pm 6e-03$	$0.95 \pm 1e-03$	$0.65 \pm 1e-03$	$0.66 \pm 6e-03$
	Shape	$0.99 \pm 4e-04$	$0.81 \pm 2e-03$	$1.00 \pm 5e-06$	$1.00 \pm 6e-05$
	Wall hue	$0.33 \pm 3e-03$	$0.84 \pm 4e-03$	$0.19 \pm 4e-03$	$0.53 \pm 3e-03$
	Floor hue	$0.39 \pm 3e-03$	$0.83 \pm 4e-03$	$0.25 \pm 4e-03$	$0.42 \pm 2e-03$
C-Sample \uparrow	Object hue	$0.97 \pm 8e-04$	$0.99 \pm 8e-04$	$0.96 \pm 1e-03$	$0.97 \pm 5e-04$
	Shape	$0.98 \pm 1e-03$	$0.99 \pm 4e-04$	$0.98 \pm 7e-04$	$0.98 \pm 8e-04$
	Wall hue	$0.98 \pm 5e-04$	$0.99 \pm 6e-04$	$0.96 \pm 2e-03$	$0.98 \pm 1e-03$
	Floor hue	$0.98 \pm 1e-03$	$0.99 \pm 5e-04$	$0.96 \pm 4e-04$	$0.98 \pm 6e-04$
GC-Sample \uparrow	Object hue	$0.97 \pm 6e-04$	$0.99 \pm 5e-04$	$0.96 \pm 9e-04$	$0.98 \pm 6e-04$
	Shape	$0.98 \pm 6e-04$	$0.99 \pm 5e-04$	$0.98 \pm 5e-04$	$0.98 \pm 3e-04$
	Wall hue	$0.98 \pm 7e-04$	$0.99 \pm 3e-04$	$0.97 \pm 1e-03$	$0.98 \pm 1e-03$
	Floor hue	$0.98 \pm 1e-03$	$0.99 \pm 5e-04$	$0.97 \pm 6e-04$	$0.98 \pm 4e-04$

Table 24: **Consistency** on the **3D-Shapes** dataset for **SSM-SKD**.

Category	Type	Shape	Floor hue	Wall hue	Object hue
C-Swap \uparrow	Shape	$0.71 \pm 4e-03$	$1.00 \pm 8e-04$	$1.00 \pm 6e-04$	$0.93 \pm 3e-03$
	Floor hue	$1.00 \pm 1e-05$	$0.96 \pm 1e-03$	$1.00 \pm 8e-05$	$1.00 \pm 2e-03$
	Wall hue	$1.00 \pm 7e-06$	$1.00 \pm 4e-05$	$0.86 \pm 5e-03$	$1.00 \pm 4e-05$
	Object hue	$0.96 \pm 2e-03$	$1.00 \pm 3e-04$	$1.00 \pm 1e-04$	$0.77 \pm 4e-03$
C-Sample \uparrow	Shape	$0.98 \pm 8e-04$	$0.98 \pm 5e-04$	$0.97 \pm 1e-03$	$0.98 \pm 1e-03$
	Floor hue	$0.99 \pm 3e-04$	$0.99 \pm 4e-04$	$0.98 \pm 9e-04$	$0.98 \pm 6e-04$
	Wall hue	$0.99 \pm 5e-04$	$0.98 \pm 1e-03$	$0.98 \pm 7e-04$	$0.98 \pm 4e-04$
	Object hue	$0.99 \pm 5e-04$	$0.98 \pm 7e-04$	$0.97 \pm 6e-04$	$0.98 \pm 7e-04$
GC-Sample \uparrow	Shape	$0.98 \pm 9e-04$	$0.98 \pm 8e-04$	$0.98 \pm 7e-04$	$0.98 \pm 2e-03$
	Floor hue	$0.99 \pm 5e-04$	$0.99 \pm 7e-04$	$0.98 \pm 1e-03$	$0.98 \pm 5e-04$
	Wall hue	$0.99 \pm 3e-04$	$0.98 \pm 6e-04$	$0.98 \pm 6e-04$	$0.98 \pm 5e-04$
	Object hue	$0.99 \pm 5e-04$	$0.98 \pm 4e-04$	$0.98 \pm 1e-03$	$0.98 \pm 9e-04$