

---

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

---

Tal Barami\* Nimrod Berman\* Ilan Naiman\* Amos H. Hason Rotem Ezra Omri Azencot

Faculty of Computer and Information Science

Ben-Gurion University of the Negev

{baramit, bermann, naimani, hasona, rotemez}@post.bgu.ac.il

azencot@bgu.ac.il

## dSprites (Static) Results

Table 1: **M-Swap** on the **dSprites (Static)** dataset for **Sparse-AE**.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.11 \pm 2e-03$	$0.33 \pm 3e-03$	$0.12 \pm 1e-03$	$0.13 \pm 5e-03$	$0.17 \pm 1e-03$	$0.33 \pm 4e-03$
	Shape	$0.11 \pm 5e-03$	$0.33 \pm 4e-03$	$0.12 \pm 2e-03$	$0.13 \pm 5e-03$	$0.17 \pm 8e-04$	$0.33 \pm 4e-03$
	Posx	$0.11 \pm 4e-03$	$0.33 \pm 4e-03$	$0.12 \pm 4e-03$	$0.13 \pm 3e-03$	$0.17 \pm 9e-04$	$0.33 \pm 1e-02$
	Posy	$0.11 \pm 6e-03$	$0.33 \pm 2e-03$	$0.12 \pm 1e-03$	$0.13 \pm 3e-03$	$0.17 \pm 5e-04$	$0.33 \pm 4e-03$
	Scale speed	$0.11 \pm 4e-03$	$0.33 \pm 4e-03$	$0.12 \pm 4e-03$	$0.13 \pm 5e-03$	$0.17 \pm 7e-04$	$0.33 \pm 8e-03$
	Rotation speed	$0.11 \pm 7e-03$	$0.33 \pm 1e-03$	$0.12 \pm 4e-03$	$0.13 \pm 3e-03$	$0.17 \pm 1e-03$	$0.33 \pm 8e-03$
Two-factor	Dynamic	$0.11 \pm 3e-03$	$0.33 \pm 3e-03$	$0.12 \pm 3e-03$	$0.13 \pm 3e-03$	$0.17 \pm 6e-04$	$0.33 \pm 6e-03$
	Static	$0.11 \pm 8e-03$	$0.33 \pm 2e-03$	$0.12 \pm 3e-03$	$0.13 \pm 3e-03$	$0.17 \pm 4e-04$	$0.33 \pm 8e-03$

Table 2: **M-Swap** on the **dSprites (Static)** dataset for **VAE**.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.10 \pm 5e-04$	$0.33 \pm 7e-04$	$0.13 \pm 7e-04$	$0.13 \pm 1e-03$	$0.17 \pm 3e-03$	$0.32 \pm 1e-03$
	Shape	$0.10 \pm 2e-03$	$0.33 \pm 2e-03$	$0.12 \pm 3e-04$	$0.13 \pm 1e-03$	$0.17 \pm 4e-03$	$0.32 \pm 1e-03$
	Posx	$0.10 \pm 1e-03$	$0.33 \pm 1e-03$	$0.12 \pm 2e-04$	$0.13 \pm 2e-03$	$0.17 \pm 2e-03$	$0.32 \pm 1e-03$
	Posy	$0.10 \pm 5e-04$	$0.34 \pm 1e-03$	$0.13 \pm 3e-04$	$0.13 \pm 2e-04$	$0.17 \pm 3e-03$	$0.32 \pm 4e-04$
	Scale speed	$0.10 \pm 8e-04$	$0.33 \pm 2e-03$	$0.13 \pm 6e-04$	$0.13 \pm 8e-04$	$0.17 \pm 4e-03$	$0.32 \pm 1e-03$
	Rotation speed	$0.10 \pm 4e-04$	$0.33 \pm 1e-03$	$0.13 \pm 4e-04$	$0.13 \pm 7e-04$	$0.17 \pm 3e-03$	$0.32 \pm 2e-03$
Two-factor	Dynamic	$0.10 \pm 1e-04$	$0.33 \pm 1e-03$	$0.13 \pm 8e-04$	$0.13 \pm 9e-04$	$0.17 \pm 3e-03$	$0.32 \pm 7e-04$
	Static	$0.10 \pm 5e-04$	$0.33 \pm 1e-03$	$0.13 \pm 2e-04$	$0.13 \pm 5e-04$	$0.17 \pm 2e-03$	$0.32 \pm 2e-03$

---

\*Equal contribution

Table 3: **M-Swap** on the **dSprites (Static)** dataset for  $\beta$ -VAE.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.34 \pm 7e-03$	$0.35 \pm 4e-03$	$0.15 \pm 6e-03$	$0.15 \pm 5e-03$	$0.18 \pm 6e-03$	$0.35 \pm 2e-03$
	Shape	$0.14 \pm 3e-03$	$0.47 \pm 8e-03$	$0.14 \pm 7e-03$	$0.14 \pm 4e-03$	$0.28 \pm 6e-03$	$0.37 \pm 4e-03$
	Posx	$0.15 \pm 4e-03$	$0.35 \pm 1e-02$	$0.22 \pm 4e-03$	$0.19 \pm 6e-03$	$0.18 \pm 2e-03$	$0.35 \pm 3e-03$
	Posy	$0.15 \pm 5e-03$	$0.35 \pm 1e-02$	$0.19 \pm 3e-03$	$0.22 \pm 6e-03$	$0.18 \pm 2e-03$	$0.35 \pm 5e-03$
	Scale speed	$0.14 \pm 3e-03$	$0.35 \pm 1e-02$	$0.14 \pm 8e-03$	$0.14 \pm 4e-03$	$0.26 \pm 7e-03$	$0.34 \pm 4e-03$
	Rotation speed	$0.14 \pm 3e-03$	$0.42 \pm 1e-02$	$0.14 \pm 9e-03$	$0.14 \pm 5e-03$	$0.20 \pm 5e-03$	$0.37 \pm 6e-03$
Two-factor	Dynamic	$0.14 \pm 2e-03$	$0.43 \pm 7e-03$	$0.14 \pm 5e-03$	$0.15 \pm 9e-03$	$0.30 \pm 7e-03$	$0.38 \pm 7e-03$
	Static	$0.87 \pm 1e-03$	$0.53 \pm 6e-03$	$0.80 \pm 1e-03$	$0.75 \pm 2e-03$	$0.31 \pm 6e-03$	$0.42 \pm 5e-03$

Table 4: **M-Swap** on the **dSprites (Static)** dataset for MGP-VAE.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.16 \pm 4e-03$	$0.35 \pm 5e-03$	$0.15 \pm 5e-03$	$0.14 \pm 7e-03$	$0.27 \pm 4e-03$	$0.34 \pm 7e-03$
	Shape	$0.14 \pm 4e-03$	$0.59 \pm 7e-03$	$0.28 \pm 5e-03$	$0.15 \pm 6e-03$	$0.30 \pm 6e-03$	$0.41 \pm 5e-03$
	Posx	$0.14 \pm 3e-03$	$0.35 \pm 5e-03$	$0.20 \pm 5e-03$	$0.16 \pm 6e-03$	$0.19 \pm 2e-03$	$0.34 \pm 8e-03$
	Posy	$0.19 \pm 3e-03$	$0.38 \pm 7e-03$	$0.18 \pm 6e-03$	$0.73 \pm 3e-03$	$0.19 \pm 4e-03$	$0.39 \pm 7e-03$
	Scale speed	$0.22 \pm 4e-03$	$0.35 \pm 7e-03$	$0.14 \pm 6e-03$	$0.14 \pm 6e-03$	$0.29 \pm 3e-03$	$0.34 \pm 6e-03$
	Rotation speed	$1.11 \pm 0e+00$	$1.33 \pm 0e+00$	$1.12 \pm 0e+00$	$1.12 \pm 0e+00$	$1.17 \pm 0e+00$	$0.00 \pm 0e+00$
Two-factor	Dynamic	$0.22 \pm 7e-03$	$0.34 \pm 8e-03$	$0.15 \pm 5e-03$	$0.14 \pm 5e-03$	$0.29 \pm 9e-03$	$0.33 \pm 3e-03$
	Static	$0.38 \pm 1e-02$	$0.78 \pm 3e-03$	$0.80 \pm 1e-03$	$0.79 \pm 2e-03$	$0.51 \pm 1e-03$	$0.52 \pm 4e-03$

Table 5: **M-Swap** on the **dSprites (Static)** dataset for SKD.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.19 \pm 1e-02$	$0.34 \pm 6e-03$	$0.18 \pm 8e-03$	$0.13 \pm 7e-03$	$0.18 \pm 4e-03$	$0.34 \pm 1e-02$
	Shape	$0.11 \pm 4e-03$	$0.38 \pm 7e-03$	$0.13 \pm 2e-03$	$0.13 \pm 4e-03$	$0.26 \pm 5e-03$	$0.34 \pm 5e-03$
	Posx	$0.21 \pm 4e-03$	$0.34 \pm 6e-03$	$0.26 \pm 6e-03$	$0.19 \pm 8e-03$	$0.18 \pm 5e-03$	$0.35 \pm 1e-02$
	Posy	$0.13 \pm 5e-03$	$0.35 \pm 8e-03$	$0.15 \pm 7e-03$	$0.29 \pm 4e-03$	$0.17 \pm 6e-03$	$0.35 \pm 9e-03$
	Scale speed	$0.11 \pm 5e-03$	$0.41 \pm 1e-02$	$0.13 \pm 3e-03$	$0.13 \pm 3e-03$	$0.46 \pm 1e-02$	$0.34 \pm 6e-03$
	Rotation speed	$0.11 \pm 5e-03$	$0.36 \pm 9e-03$	$0.13 \pm 2e-03$	$0.13 \pm 4e-03$	$0.18 \pm 5e-03$	$0.34 \pm 9e-03$
Two-factor	Dynamic	$0.12 \pm 7e-03$	$0.45 \pm 7e-03$	$0.13 \pm 5e-03$	$0.14 \pm 5e-03$	$0.48 \pm 1e-02$	$0.36 \pm 9e-03$
	Static	$0.84 \pm 8e-03$	$0.63 \pm 7e-03$	$0.80 \pm 3e-03$	$0.79 \pm 3e-03$	$0.31 \pm 1e-02$	$0.65 \pm 1e-02$

Table 6: **M-Swap** on the **dSprites (Static)** dataset for SSM-SKD.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.41 \pm 7e-03$	$0.34 \pm 8e-03$	$0.13 \pm 4e-03$	$0.12 \pm 6e-03$	$0.17 \pm 5e-03$	$0.33 \pm 1e-02$
	Shape	$0.12 \pm 7e-03$	$0.37 \pm 5e-03$	$0.13 \pm 4e-03$	$0.13 \pm 4e-03$	$0.18 \pm 5e-03$	$0.33 \pm 1e-02$
	Posx	$0.11 \pm 7e-03$	$0.33 \pm 8e-03$	$0.73 \pm 6e-03$	$0.12 \pm 5e-03$	$0.17 \pm 4e-03$	$0.33 \pm 1e-02$
	Posy	$0.12 \pm 7e-03$	$0.36 \pm 1e-02$	$0.13 \pm 4e-03$	$0.67 \pm 3e-03$	$0.18 \pm 3e-03$	$0.34 \pm 1e-02$
	Scale speed	$0.14 \pm 1e-02$	$0.36 \pm 1e-02$	$0.13 \pm 4e-03$	$0.13 \pm 6e-03$	$0.67 \pm 7e-03$	$0.33 \pm 9e-03$
	Rotation speed	$0.12 \pm 8e-03$	$0.45 \pm 8e-03$	$0.13 \pm 3e-03$	$0.14 \pm 8e-03$	$0.17 \pm 2e-03$	$0.58 \pm 1e-02$
Two-factor	Dynamic	$0.16 \pm 2e-02$	$0.67 \pm 7e-03$	$0.13 \pm 6e-03$	$0.15 \pm 3e-03$	$0.66 \pm 5e-03$	$0.72 \pm 3e-03$
	Static	$0.74 \pm 3e-02$	$0.43 \pm 1e-02$	$0.78 \pm 3e-03$	$0.73 \pm 5e-03$	$0.22 \pm 7e-03$	$0.34 \pm 6e-03$

Table 7: **M-GSample** on the **dSprites (Static)** dataset for Sparse-AE.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.11 \pm 8e-03$	$0.33 \pm 2e-03$	$0.12 \pm 3e-03$	$0.13 \pm 1e-03$	$0.17 \pm 6e-04$	$0.33 \pm 6e-03$
	Shape	$0.11 \pm 4e-03$	$0.33 \pm 3e-03$	$0.12 \pm 3e-03$	$0.13 \pm 1e-03$	$0.17 \pm 1e-04$	$0.32 \pm 3e-03$
	Posx	$0.11 \pm 4e-03$	$0.33 \pm 2e-03$	$0.12 \pm 4e-03$	$0.13 \pm 6e-03$	$0.17 \pm 7e-04$	$0.33 \pm 7e-03$
	Posy	$0.11 \pm 2e-03$	$0.33 \pm 2e-03$	$0.12 \pm 4e-03$	$0.13 \pm 2e-03$	$0.17 \pm 1e-03$	$0.33 \pm 8e-03$
	Scale speed	$0.11 \pm 4e-03$	$0.33 \pm 9e-04$	$0.12 \pm 2e-03$	$0.13 \pm 3e-03$	$0.17 \pm 5e-04$	$0.33 \pm 7e-03$
	Rotation speed	$0.11 \pm 5e-03$	$0.33 \pm 2e-03$	$0.12 \pm 3e-03$	$0.13 \pm 3e-03$	$0.17 \pm 8e-04$	$0.33 \pm 5e-03$
Two-factor	Dynamic	$0.11 \pm 3e-03$	$0.33 \pm 4e-03$	$0.12 \pm 2e-03$	$0.13 \pm 2e-03$	$0.17 \pm 6e-04$	$0.33 \pm 8e-03$
	Static	$0.11 \pm 2e-03$	$0.33 \pm 2e-03$	$0.12 \pm 2e-03$	$0.13 \pm 2e-03$	$0.17 \pm 6e-04$	$0.33 \pm 6e-03$

Table 8: **M-GSample** on the **dSprites (Static)** dataset for **VAE**.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.11 \pm 4e-03$	$0.33 \pm 4e-03$	$0.13 \pm 2e-03$	$0.12 \pm 4e-03$	$0.17 \pm 5e-03$	$0.33 \pm 2e-03$
	Shape	$0.11 \pm 2e-03$	$0.33 \pm 2e-03$	$0.13 \pm 1e-03$	$0.13 \pm 6e-03$	$0.17 \pm 3e-03$	$0.33 \pm 4e-03$
	Posx	$0.11 \pm 3e-03$	$0.33 \pm 4e-03$	$0.13 \pm 3e-03$	$0.13 \pm 4e-03$	$0.17 \pm 6e-03$	$0.33 \pm 1e-03$
	Posy	$0.11 \pm 1e-03$	$0.33 \pm 7e-03$	$0.13 \pm 1e-03$	$0.13 \pm 4e-03$	$0.17 \pm 4e-03$	$0.33 \pm 2e-03$
	Scale speed	$0.11 \pm 4e-03$	$0.33 \pm 4e-03$	$0.13 \pm 2e-03$	$0.13 \pm 4e-03$	$0.17 \pm 3e-03$	$0.33 \pm 4e-03$
	Rotation speed	$0.11 \pm 4e-03$	$0.33 \pm 6e-03$	$0.12 \pm 2e-03$	$0.13 \pm 4e-03$	$0.17 \pm 3e-03$	$0.33 \pm 3e-03$
Two-factor	Dynamic	$0.11 \pm 3e-03$	$0.33 \pm 5e-03$	$0.13 \pm 2e-03$	$0.12 \pm 3e-03$	$0.17 \pm 5e-03$	$0.34 \pm 3e-03$
	Static	$0.11 \pm 3e-03$	$0.33 \pm 2e-03$	$0.12 \pm 3e-03$	$0.12 \pm 2e-03$	$0.17 \pm 4e-03$	$0.33 \pm 6e-03$

Table 9: **M-GSample** on the **dSprites (Static)** dataset for  $\beta$ -VAE.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.36 \pm 5e-03$	$0.34 \pm 3e-03$	$0.14 \pm 5e-03$	$0.14 \pm 3e-03$	$0.16 \pm 5e-03$	$0.33 \pm 6e-03$
	Shape	$0.11 \pm 3e-03$	$0.49 \pm 9e-03$	$0.13 \pm 4e-03$	$0.12 \pm 4e-03$	$0.29 \pm 5e-03$	$0.35 \pm 1e-02$
	Posx	$0.13 \pm 5e-03$	$0.34 \pm 8e-03$	$0.20 \pm 5e-03$	$0.18 \pm 5e-03$	$0.16 \pm 5e-03$	$0.33 \pm 8e-03$
	Posy	$0.13 \pm 5e-03$	$0.33 \pm 6e-03$	$0.18 \pm 6e-03$	$0.20 \pm 6e-03$	$0.16 \pm 4e-03$	$0.33 \pm 7e-03$
	Scale speed	$0.11 \pm 5e-03$	$0.34 \pm 4e-03$	$0.13 \pm 6e-03$	$0.12 \pm 4e-03$	$0.26 \pm 6e-03$	$0.34 \pm 9e-03$
	Rotation speed	$0.11 \pm 5e-03$	$0.42 \pm 7e-03$	$0.13 \pm 2e-03$	$0.12 \pm 2e-03$	$0.20 \pm 3e-03$	$0.38 \pm 4e-03$
Two-factor	Dynamic	$0.11 \pm 3e-03$	$0.42 \pm 9e-03$	$0.12 \pm 5e-03$	$0.13 \pm 4e-03$	$0.31 \pm 4e-03$	$0.38 \pm 7e-03$
	Static	$0.87 \pm 2e-03$	$0.54 \pm 8e-04$	$0.80 \pm 2e-03$	$0.76 \pm 3e-03$	$0.31 \pm 3e-03$	$0.42 \pm 5e-03$

Table 10: **M-GSample** on the **dSprites (Static)** dataset for **MGP-VAE**.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.11 \pm 3e-03$	$0.33 \pm 3e-03$	$0.12 \pm 4e-03$	$0.13 \pm 6e-03$	$0.16 \pm 5e-03$	$0.33 \pm 4e-03$
	Shape	$0.11 \pm 7e-03$	$0.33 \pm 5e-03$	$0.12 \pm 5e-03$	$0.13 \pm 6e-03$	$0.16 \pm 8e-03$	$0.33 \pm 7e-03$
	Posx	$0.11 \pm 6e-03$	$0.34 \pm 6e-03$	$0.13 \pm 5e-03$	$0.13 \pm 5e-03$	$0.17 \pm 4e-03$	$0.33 \pm 8e-03$
	Posy	$0.11 \pm 5e-03$	$0.33 \pm 4e-03$	$0.13 \pm 3e-03$	$0.14 \pm 2e-03$	$0.16 \pm 4e-03$	$0.33 \pm 6e-03$
	Scale speed	$0.11 \pm 5e-03$	$0.34 \pm 4e-03$	$0.13 \pm 5e-03$	$0.12 \pm 3e-03$	$0.16 \pm 4e-03$	$0.33 \pm 2e-03$
	Rotation speed	$1.11 \pm 0e+00$	$1.33 \pm 0e+00$	$1.12 \pm 0e+00$	$1.12 \pm 0e+00$	$1.17 \pm 0e+00$	$0.00 \pm 0e+00$
Two-factor	Dynamic	$0.11 \pm 4e-03$	$0.34 \pm 3e-03$	$0.13 \pm 4e-03$	$0.13 \pm 2e-03$	$0.16 \pm 4e-03$	$0.33 \pm 5e-03$
	Static	$0.15 \pm 4e-03$	$0.38 \pm 7e-03$	$0.48 \pm 3e-03$	$0.48 \pm 5e-03$	$0.26 \pm 6e-03$	$0.37 \pm 5e-03$

Table 11: **M-GSample** on the **dSprites (Static)** dataset for **SKD**.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.21 \pm 6e-03$	$0.34 \pm 7e-03$	$0.19 \pm 9e-03$	$0.14 \pm 9e-03$	$0.18 \pm 6e-03$	$0.34 \pm 7e-03$
	Shape	$0.12 \pm 4e-03$	$0.38 \pm 1e-02$	$0.13 \pm 5e-03$	$0.13 \pm 4e-03$	$0.28 \pm 7e-03$	$0.35 \pm 3e-03$
	Posx	$0.23 \pm 6e-03$	$0.34 \pm 7e-03$	$0.27 \pm 7e-03$	$0.21 \pm 6e-03$	$0.18 \pm 5e-03$	$0.35 \pm 7e-03$
	Posy	$0.14 \pm 4e-03$	$0.36 \pm 5e-03$	$0.16 \pm 4e-03$	$0.33 \pm 5e-03$	$0.18 \pm 3e-03$	$0.36 \pm 7e-03$
	Scale speed	$0.12 \pm 3e-03$	$0.43 \pm 9e-03$	$0.13 \pm 4e-03$	$0.13 \pm 3e-03$	$0.50 \pm 5e-03$	$0.36 \pm 1e-02$
	Rotation speed	$0.12 \pm 6e-03$	$0.36 \pm 1e-02$	$0.13 \pm 1e-03$	$0.14 \pm 5e-03$	$0.19 \pm 3e-03$	$0.35 \pm 6e-03$
Two-factor	Dynamic	$0.13 \pm 3e-03$	$0.47 \pm 9e-03$	$0.13 \pm 8e-03$	$0.14 \pm 7e-03$	$0.53 \pm 6e-03$	$0.38 \pm 7e-03$
	Static	$0.84 \pm 1e-02$	$0.65 \pm 4e-03$	$0.80 \pm 2e-03$	$0.79 \pm 2e-03$	$0.32 \pm 5e-03$	$0.67 \pm 1e-02$

Table 12: **M-GSample** on the **dSprites (Static)** dataset for **SSM-SKD**.

Category	Type	Color	Shape	Posx	Posy	Scale speed	Rotation speed
Uni-factor	Color	$0.44 \pm 1e-02$	$0.34 \pm 5e-03$	$0.13 \pm 4e-03$	$0.13 \pm 3e-03$	$0.17 \pm 5e-03$	$0.33 \pm 8e-03$
	Shape	$0.13 \pm 2e-03$	$0.42 \pm 1e-02$	$0.12 \pm 4e-03$	$0.14 \pm 3e-03$	$0.19 \pm 4e-03$	$0.34 \pm 5e-03$
	Posx	$0.13 \pm 4e-03$	$0.33 \pm 1e-02$	$0.76 \pm 5e-03$	$0.13 \pm 3e-03$	$0.17 \pm 5e-03$	$0.34 \pm 4e-03$
	Posy	$0.14 \pm 1e-03$	$0.38 \pm 6e-03$	$0.13 \pm 2e-03$	$0.69 \pm 3e-03$	$0.19 \pm 6e-03$	$0.35 \pm 9e-03$
	Scale speed	$0.18 \pm 1e-02$	$0.40 \pm 5e-03$	$0.13 \pm 4e-03$	$0.13 \pm 3e-03$	$0.69 \pm 4e-03$	$0.35 \pm 8e-03$
	Rotation speed	$0.12 \pm 4e-03$	$0.51 \pm 7e-03$	$0.13 \pm 3e-03$	$0.15 \pm 4e-03$	$0.18 \pm 6e-03$	$0.65 \pm 9e-03$
Two-factor	Dynamic	$0.20 \pm 6e-03$	$0.71 \pm 9e-03$	$0.12 \pm 6e-03$	$0.16 \pm 8e-03$	$0.71 \pm 1e-02$	$0.76 \pm 5e-03$
	Static	$0.76 \pm 2e-02$	$0.50 \pm 7e-03$	$0.79 \pm 3e-03$	$0.74 \pm 2e-03$	$0.23 \pm 4e-03$	$0.37 \pm 6e-03$

Table 13: **DCI** on the **dSprites (Static)** dataset for **Sparse-AE**.

<b>None</b>	DCI-M $\uparrow$	DCI-C $\uparrow$	DCI-E $\uparrow$
Color	$0.00 \pm 2e-03$	$0.68 \pm 1e-03$	$0.11 \pm 1e-02$
Shape	$0.00 \pm 5e-04$	$0.68 \pm 4e-04$	$0.33 \pm 1e-02$
Posx	$0.00 \pm 5e-04$	$0.68 \pm 1e-03$	$0.13 \pm 7e-03$
Posy	$0.00 \pm 4e-04$	$0.68 \pm 5e-04$	$0.12 \pm 9e-03$
Scale speed	$0.00 \pm 4e-04$	$0.68 \pm 1e-03$	$0.17 \pm 1e-02$
Rotation speed	$0.00 \pm 5e-04$	$0.68 \pm 5e-04$	$0.34 \pm 2e-02$

Table 14: **DCI** on the **dSprites (Static)** dataset for **VAE**.

<b>None</b>	DCI-M $\uparrow$	DCI-C $\uparrow$	DCI-E $\uparrow$
Color	$0.00 \pm 1e-03$	$0.68 \pm 1e-03$	$0.11 \pm 5e-03$
Shape	$0.00 \pm 2e-04$	$0.68 \pm 2e-03$	$0.33 \pm 2e-02$
Posx	$0.00 \pm 2e-03$	$0.68 \pm 1e-03$	$0.14 \pm 2e-02$
Posy	$0.00 \pm 1e-03$	$0.68 \pm 8e-04$	$0.12 \pm 1e-02$
Scale speed	$0.00 \pm 6e-04$	$0.68 \pm 1e-03$	$0.18 \pm 2e-02$
Rotation speed	$0.00 \pm 2e-04$	$0.69 \pm 2e-03$	$0.34 \pm 2e-02$

Table 15: **DCI** on the **dSprites (Static)** dataset for  $\beta$ -**VAE**.

<b>None</b>	DCI-M $\uparrow$	DCI-C $\uparrow$	DCI-E $\uparrow$
Color	$0.26 \pm 4e-03$	$0.79 \pm 1e-03$	$0.66 \pm 1e-02$
Shape	$0.36 \pm 5e-03$	$0.77 \pm 3e-03$	$0.82 \pm 8e-03$
Posx	$0.25 \pm 1e-02$	$0.76 \pm 7e-04$	$0.67 \pm 2e-02$
Posy	$0.21 \pm 9e-03$	$0.76 \pm 2e-03$	$0.64 \pm 9e-03$
Scale speed	$0.34 \pm 1e-02$	$0.74 \pm 1e-03$	$0.79 \pm 6e-03$
Rotation speed	$0.10 \pm 4e-03$	$0.74 \pm 5e-03$	$0.59 \pm 2e-02$

Table 16: **DCI** on the **dSprites (Static)** dataset for **MGP-VAE**.

<b>None</b>	DCI-M $\uparrow$	DCI-C $\uparrow$	DCI-E $\uparrow$
Color	$0.10 \pm 5e-03$	$0.43 \pm 5e-03$	$0.39 \pm 1e-02$
Shape	$0.12 \pm 5e-03$	$0.48 \pm 2e-02$	$0.47 \pm 1e-02$
Posx	$0.04 \pm 2e-03$	$0.39 \pm 3e-03$	$0.22 \pm 9e-03$
Posy	$0.05 \pm 3e-03$	$0.43 \pm 6e-03$	$0.20 \pm 2e-02$
Scale speed	$0.13 \pm 5e-03$	$0.50 \pm 7e-03$	$0.36 \pm 5e-03$
Rotation speed	nan	$0.41 \pm 8e-03$	$0.40 \pm 2e-02$

Table 17: **DCI** on the **dSprites (Static)** dataset for **SKD**.

<b>None</b>	DCI-M $\uparrow$	DCI-C $\uparrow$	DCI-E $\uparrow$
Color	$0.14 \pm 7e-04$	$0.56 \pm 2e-03$	$0.72 \pm 7e-04$
Shape	$0.11 \pm 3e-03$	$0.58 \pm 2e-03$	$0.68 \pm 5e-04$
Posx	$0.10 \pm 6e-04$	$0.56 \pm 6e-04$	$0.67 \pm 7e-04$
Posy	$0.06 \pm 2e-04$	$0.60 \pm 3e-03$	$0.70 \pm 9e-04$
Scale speed	$0.11 \pm 1e-02$	$0.55 \pm 9e-04$	$0.31 \pm 1e-03$
Rotation speed	$0.06 \pm 2e-03$	$0.56 \pm 4e-03$	$0.44 \pm 4e-03$

Table 18: **DCI** on the **dSprites (Static)** dataset for **SSM-SKD**.

<b>None</b>	DCI-M $\uparrow$	DCI-C $\uparrow$	DCI-E $\uparrow$
Color	$0.70 \pm 6e-03$	$0.95 \pm 5e-03$	$1.00 \pm 0e+00$
Shape	$0.48 \pm 6e-04$	$0.85 \pm 5e-04$	$0.98 \pm 7e-04$
Posx	$0.84 \pm 9e-03$	$0.87 \pm 2e-03$	$0.92 \pm 5e-04$
Posy	$0.84 \pm 8e-04$	$0.90 \pm 4e-04$	$0.97 \pm 0e+00$
Scale speed	$0.66 \pm 1e-02$	$0.77 \pm 1e-03$	$0.97 \pm 0e+00$
Rotation speed	$0.65 \pm 5e-04$	$0.79 \pm 2e-04$	$0.84 \pm 1e-03$

Table 19: **Consistency** on the **dSprites (Static)** dataset for **Sparse-AE**.

Category	Type	Shape	Color	Posx	Posy
C-Swap $\uparrow$	Shape	$0.33 \pm 1e-03$	$0.11 \pm 2e-03$	$0.12 \pm 3e-03$	$0.13 \pm 2e-03$
	Color	$0.33 \pm 2e-03$	$0.11 \pm 2e-03$	$0.12 \pm 1e-03$	$0.13 \pm 4e-03$
	Posx	$0.33 \pm 3e-03$	$0.11 \pm 4e-03$	$0.13 \pm 2e-03$	$0.13 \pm 2e-03$
	Posy	$0.33 \pm 3e-03$	$0.11 \pm 3e-03$	$0.13 \pm 2e-03$	$0.13 \pm 2e-03$
C-Sample $\uparrow$	Shape	$0.84 \pm 6e-03$	$0.82 \pm 2e-03$	$0.65 \pm 3e-03$	$0.62 \pm 4e-03$
	Color	$0.87 \pm 2e-03$	$0.78 \pm 2e-03$	$0.75 \pm 2e-03$	$0.70 \pm 2e-03$
	Posx	$0.88 \pm 4e-03$	$0.79 \pm 4e-03$	$0.70 \pm 3e-03$	$0.68 \pm 3e-03$
	Posy	$0.86 \pm 1e-03$	$0.77 \pm 2e-03$	$0.70 \pm 3e-03$	$0.66 \pm 2e-03$
GC-Sample $\uparrow$	Shape	$0.88 \pm 4e-03$	$0.84 \pm 3e-03$	$0.72 \pm 4e-03$	$0.70 \pm 5e-03$
	Color	$0.90 \pm 3e-03$	$0.83 \pm 3e-03$	$0.81 \pm 2e-03$	$0.78 \pm 2e-03$
	Posx	$0.91 \pm 4e-03$	$0.84 \pm 4e-03$	$0.76 \pm 2e-03$	$0.77 \pm 6e-03$
	Posy	$0.90 \pm 3e-03$	$0.83 \pm 2e-03$	$0.75 \pm 2e-03$	$0.75 \pm 2e-03$

Table 20: **Consistency** on the **dSprites (Static)** dataset for **VAE**.

Category	Type	Posx	Shape	Posy	Color
C-Swap $\uparrow$	Posx	$0.12 \pm 1e-03$	$0.33 \pm 9e-04$	$0.13 \pm 1e-03$	$0.11 \pm 9e-04$
	Shape	$0.12 \pm 1e-03$	$0.33 \pm 2e-03$	$0.13 \pm 1e-03$	$0.11 \pm 2e-04$
	Posy	$0.12 \pm 6e-04$	$0.33 \pm 1e-03$	$0.13 \pm 9e-04$	$0.11 \pm 8e-04$
	Color	$0.12 \pm 1e-03$	$0.33 \pm 1e-03$	$0.13 \pm 8e-04$	$0.11 \pm 4e-04$
C-Sample $\uparrow$	Posx	$0.64 \pm 5e-03$	$0.96 \pm 3e-03$	$0.85 \pm 7e-03$	$0.95 \pm 6e-03$
	Shape	$0.64 \pm 8e-03$	$0.96 \pm 5e-03$	$0.86 \pm 1e-02$	$0.95 \pm 5e-03$
	Posy	$0.65 \pm 5e-03$	$0.96 \pm 3e-03$	$0.85 \pm 3e-03$	$0.95 \pm 5e-03$
	Color	$0.64 \pm 2e-03$	$0.96 \pm 6e-03$	$0.86 \pm 5e-03$	$0.95 \pm 3e-03$
GC-Sample $\uparrow$	Posx	$0.88 \pm 1e-03$	$0.97 \pm 2e-03$	$0.88 \pm 8e-03$	$0.96 \pm 9e-04$
	Shape	$0.88 \pm 3e-03$	$0.97 \pm 4e-03$	$0.89 \pm 9e-03$	$0.96 \pm 3e-03$
	Posy	$0.88 \pm 2e-03$	$0.97 \pm 4e-03$	$0.89 \pm 8e-03$	$0.96 \pm 3e-03$
	Color	$0.88 \pm 2e-03$	$0.97 \pm 4e-03$	$0.88 \pm 9e-03$	$0.96 \pm 5e-03$

Table 21: **Consistency** on the **dSprites (Static)** dataset for  $\beta$ -VAE.

Category	Type	Posx	Color	Posy	Shape
C-Swap $\uparrow$	Posx	$0.22 \pm 4e-03$	$0.54 \pm 9e-03$	$0.24 \pm 1e-02$	$0.79 \pm 3e-03$
	Color	$0.62 \pm 4e-03$	$0.34 \pm 4e-03$	$0.58 \pm 7e-03$	$0.76 \pm 3e-03$
	Posy	$0.24 \pm 2e-03$	$0.55 \pm 4e-03$	$0.21 \pm 5e-03$	$0.78 \pm 3e-03$
	Shape	$0.80 \pm 2e-03$	$0.87 \pm 2e-03$	$0.77 \pm 2e-03$	$0.47 \pm 1e-02$
C-Sample $\uparrow$	Posx	$0.98 \pm 2e-03$	$0.99 \pm 1e-03$	$0.98 \pm 1e-03$	$0.99 \pm 1e-03$
	Color	$0.96 \pm 3e-03$	$0.99 \pm 1e-03$	$0.96 \pm 2e-03$	$0.99 \pm 7e-04$
	Posy	$0.98 \pm 2e-03$	$0.99 \pm 7e-04$	$0.98 \pm 1e-03$	$0.99 \pm 8e-04$
	Shape	$0.97 \pm 2e-03$	$0.99 \pm 8e-04$	$0.98 \pm 2e-03$	$0.99 \pm 5e-04$
GC-Sample $\uparrow$	Posx	$0.98 \pm 5e-04$	$0.99 \pm 7e-04$	$0.99 \pm 1e-03$	$0.99 \pm 3e-04$
	Color	$0.97 \pm 2e-03$	$0.99 \pm 2e-04$	$0.97 \pm 3e-03$	$0.99 \pm 5e-04$
	Posy	$0.98 \pm 1e-03$	$0.99 \pm 6e-04$	$0.99 \pm 9e-04$	$0.99 \pm 8e-04$
	Shape	$0.98 \pm 2e-03$	$0.99 \pm 8e-04$	$0.99 \pm 1e-03$	$0.99 \pm 7e-04$

Table 22: **Consistency** on the **dSprites (Static)** dataset for **MGP-VAE**.

Category	Type	Posy	Shape	Posx	Color
C-Swap $\uparrow$	Posy	$0.73 \pm 4e-03$	$0.64 \pm 4e-03$	$0.48 \pm 6e-03$	$0.58 \pm 1e-02$
	Shape	$0.80 \pm 1e-03$	$0.58 \pm 6e-03$	$0.31 \pm 6e-03$	$0.73 \pm 4e-03$
	Posx	$0.75 \pm 4e-03$	$0.70 \pm 5e-03$	$0.19 \pm 7e-03$	$0.72 \pm 6e-03$
	Color	$0.79 \pm 2e-03$	$0.78 \pm 1e-03$	$0.80 \pm 2e-03$	$0.17 \pm 5e-03$
C-Sample $\uparrow$	Posy	$0.61 \pm 4e-03$	$0.98 \pm 2e-03$	$0.62 \pm 3e-03$	$0.70 \pm 3e-03$
	Shape	$0.61 \pm 2e-03$	$0.97 \pm 2e-03$	$0.62 \pm 2e-03$	$0.69 \pm 5e-03$
	Posx	$0.60 \pm 1e-03$	$0.97 \pm 2e-03$	$0.62 \pm 3e-03$	$0.67 \pm 5e-03$
	Color	$0.61 \pm 3e-03$	$0.97 \pm 2e-03$	$0.62 \pm 4e-03$	$0.69 \pm 4e-03$
GC-Sample $\uparrow$	Posy	$0.60 \pm 5e-03$	$0.98 \pm 1e-03$	$0.63 \pm 3e-03$	$0.66 \pm 3e-03$
	Shape	$0.61 \pm 5e-03$	$0.98 \pm 2e-03$	$0.63 \pm 5e-03$	$0.65 \pm 4e-03$
	Posx	$0.60 \pm 6e-03$	$0.97 \pm 7e-04$	$0.62 \pm 3e-03$	$0.64 \pm 3e-03$
	Color	$0.60 \pm 4e-03$	$0.97 \pm 3e-03$	$0.62 \pm 3e-03$	$0.66 \pm 6e-03$

Table 23: **Consistency on the dSprites (Static) dataset for SKD.**

Category	Type	Color	Posy	Shape	Posx
C-Swap $\uparrow$	Color	$0.21 \pm 2e-03$	$0.51 \pm 6e-03$	$0.60 \pm 4e-03$	$0.43 \pm 6e-03$
	Posy	$0.63 \pm 7e-03$	$0.29 \pm 5e-03$	$0.53 \pm 5e-03$	$0.55 \pm 2e-03$
	Shape	$0.88 \pm 2e-03$	$0.80 \pm 1e-03$	$0.38 \pm 1e-02$	$0.80 \pm 1e-03$
	Posx	$0.29 \pm 5e-03$	$0.34 \pm 7e-03$	$0.53 \pm 5e-03$	$0.25 \pm 8e-03$
C-Sample $\uparrow$	Color	$0.92 \pm 1e-03$	$0.89 \pm 2e-03$	$0.92 \pm 2e-03$	$0.89 \pm 2e-03$
	Posy	$0.93 \pm 3e-03$	$0.91 \pm 2e-03$	$0.92 \pm 2e-03$	$0.90 \pm 2e-03$
	Shape	$0.94 \pm 1e-03$	$0.93 \pm 1e-03$	$0.93 \pm 1e-03$	$0.92 \pm 2e-03$
	Posx	$0.91 \pm 4e-03$	$0.89 \pm 2e-03$	$0.91 \pm 1e-03$	$0.89 \pm 2e-03$
GC-Sample $\uparrow$	Color	$0.93 \pm 3e-03$	$0.91 \pm 2e-03$	$0.93 \pm 2e-03$	$0.91 \pm 1e-03$
	Posy	$0.94 \pm 2e-03$	$0.92 \pm 2e-03$	$0.93 \pm 2e-03$	$0.91 \pm 1e-03$
	Shape	$0.95 \pm 1e-03$	$0.94 \pm 3e-03$	$0.94 \pm 1e-03$	$0.93 \pm 2e-03$
	Posx	$0.93 \pm 3e-03$	$0.91 \pm 9e-04$	$0.93 \pm 1e-03$	$0.91 \pm 3e-04$

Table 24: **Consistency on the dSprites (Static) dataset for SSM-SKD.**

Category	Type	Color	Posy	Posx	Shape
C-Swap $\uparrow$	Color	$0.40 \pm 8e-03$	$0.80 \pm 1e-03$	$0.79 \pm 9e-04$	$0.85 \pm 2e-03$
	Posy	$0.83 \pm 3e-03$	$0.68 \pm 3e-03$	$0.80 \pm 2e-03$	$0.80 \pm 4e-03$
	Posx	$0.89 \pm 4e-03$	$0.80 \pm 1e-03$	$0.70 \pm 3e-03$	$0.84 \pm 4e-04$
	Shape	$0.88 \pm 2e-03$	$0.76 \pm 3e-03$	$0.80 \pm 1e-03$	$0.37 \pm 6e-03$
C-Sample $\uparrow$	Color	$0.96 \pm 2e-03$	$0.93 \pm 4e-03$	$0.93 \pm 5e-03$	$0.95 \pm 2e-03$
	Posy	$0.96 \pm 2e-03$	$0.94 \pm 1e-03$	$0.93 \pm 3e-03$	$0.93 \pm 3e-03$
	Posx	$0.97 \pm 1e-03$	$0.95 \pm 3e-03$	$0.92 \pm 7e-04$	$0.96 \pm 1e-03$
	Shape	$0.96 \pm 2e-03$	$0.93 \pm 2e-03$	$0.94 \pm 3e-03$	$0.94 \pm 8e-04$
GC-Sample $\uparrow$	Color	$0.97 \pm 1e-03$	$0.95 \pm 2e-03$	$0.94 \pm 4e-03$	$0.96 \pm 1e-03$
	Posy	$0.97 \pm 2e-03$	$0.95 \pm 1e-03$	$0.95 \pm 3e-03$	$0.94 \pm 3e-03$
	Posx	$0.97 \pm 6e-04$	$0.95 \pm 1e-03$	$0.94 \pm 9e-04$	$0.96 \pm 2e-03$
	Shape	$0.97 \pm 1e-03$	$0.94 \pm 2e-03$	$0.95 \pm 3e-03$	$0.95 \pm 2e-03$