

Supplementary Material: Robot Causal Discovery Aided by Human Interaction

Filip Edström, Thomas Hellström, Xavier de Luna

March 15, 2023

Table 1: **OUTDATED** Top performing implementations from the PC and MMHC starting points for all DAGs. Starting SHD is shown under “Start” and finishing SHD is shown under “Finish” with a 95% confidence interval. “ Δ ” shows the difference from start and to the subscripted number of questions. Results for Asia and Survey are excluded as all implementations reached 0.

DAG	N	Version	Start	5	Δ_5	15	Δ_{15}	Finish	Δ_{Finish}
Sachs	500	MMHC Assoc	0.85	0.65	-0.20	0.22	-0.63	0.07	-0.78
	500	PC Assoc	0.84	0.64	-0.20	0.22	-0.63	0.05	-0.80
	1000	MMHC Assoc	0.86	0.69	-0.18	0.33	-0.54	0.04	-0.82
	1000	PC Assoc	0.73	0.59	-0.15	0.30	-0.44	0.04	-0.69
	1500	MMHC Assoc	0.86	0.74	-0.12	0.38	-0.48	0.03	-0.83
	1500	PC Assoc	0.80	0.70	-0.09	0.37	-0.43	0.03	-0.77
	3000	MMHC Assoc	0.85	0.73	-0.12	0.39	-0.46	0.01	-0.84
	3000	PC Assoc	0.74	0.65	-0.09	0.39	-0.35	0.01	-0.73
Child	500	MMHC Assoc	0.61	0.58	-0.03	0.37	-0.23	0.11	-0.49
	500	PC Assoc	0.75	0.64	-0.11	0.39	-0.36	0.11	-0.63
	1000	MMHC HC	0.53	0.41	-0.12	0.28	-0.26	0.08	-0.46
	1000	PC HC	0.66	0.52	-0.14	0.24	-0.42	0.07	-0.59
	1500	MMHC HC	0.51	0.40	-0.12	0.23	-0.28	0.06	-0.46
	1500	PC HC	0.62	0.51	-0.10	0.23	-0.39	0.04	-0.58
	3000	MMHC HC	0.46	0.32	-0.15	0.17	-0.30	0.03	-0.43
	3000	PC HC	0.59	0.45	-0.14	0.17	-0.42	0.01	-0.59
Insurance	500	MMHC HC	0.81	0.73	-0.07	0.60	-0.20	0.48	-0.33
	500	PC HC	0.84	0.79	-0.06	0.66	-0.19	0.44	-0.40
	1000	MMHC HC	0.76	0.70	-0.06	0.58	-0.18	0.45	-0.31
	1000	PC HC	0.78	0.73	-0.05	0.60	-0.18	0.38	-0.41
	1500	MMHC HC	0.72	0.68	-0.04	0.56	-0.15	0.44	-0.28
	1500	PC HC	0.74	0.68	-0.06	0.54	-0.20	0.33	-0.41
	3000	MMHC HC	0.71	0.68	-0.03	0.56	-0.15	0.43	-0.28
	3000	PC HC	0.67	0.62	-0.05	0.50	-0.18	0.26	-0.41

Mildew	500	MMHC Assoc	0.91	0.85	-0.06	0.74	-0.17	0.57	-0.34
	500	PC Assoc	0.88	0.82	-0.06	0.68	-0.20	0.58	-0.31
	1000	MMHC HC	0.85	0.74	-0.11	0.65	-0.20	0.54	-0.31
	1000	PC HC	0.87	0.76	-0.11	0.62	-0.25	0.54	-0.33
	1500	MMHC HC	0.87	0.76	-0.11	0.63	-0.24	0.50	-0.37
	1500	PC HC	0.87	0.76	-0.11	0.55	-0.32	0.50	-0.37
	3000	MMHC HC	0.87	0.76	-0.11	0.64	-0.23	0.50	-0.37
	3000	PC HC	0.87	0.76	-0.11	0.58	-0.29	0.50	-0.37
Alarm	500	MMHC HC	0.69	0.59	-0.09	0.42	-0.27	0.27	-0.42
	500	PC HC	0.82	0.77	-0.05	0.60	-0.22	0.33	-0.49
	1000	MMHC HC	0.56	0.47	-0.10	0.32	-0.24	0.12	-0.44
	1000	PC HC	0.70	0.65	-0.05	0.48	-0.22	0.23	-0.47
	1500	MMHC HC	0.51	0.42	-0.09	0.28	-0.23	0.09	-0.42
	1500	PC HC	0.63	0.59	-0.04	0.42	-0.22	0.18	-0.45
	3000	MMHC HC	0.48	0.40	-0.09	0.31	-0.17	0.25	-0.23
	3000	PC HC	0.50	0.44	-0.06	0.27	-0.22	0.07	-0.43
Barley	500	MMHC HC	0.88	0.84	-0.04	0.75	-0.13	0.71	-0.18
	500	PC HC	0.99	0.93	-0.05	0.86	-0.13	0.71	-0.28
	1000	MMHC HC	0.85	0.81	-0.04	0.72	-0.13	0.69	-0.16
	1000	PC HC	0.97	0.93	-0.04	0.85	-0.13	0.70	-0.27
	1500	MMHC HC	0.84	0.81	-0.04	0.71	-0.14	0.67	-0.18
	1500	PC HC	0.96	0.92	-0.04	0.84	-0.12	0.70	-0.26
	3000	MMHC HC	0.78	0.75	-0.03	0.65	-0.13	0.54	-0.24
	3000	PC HC	0.86	0.82	-0.04	0.76	-0.11	0.63	-0.23
Hailfinder	500	MMHC HC	0.65	0.59	-0.06	0.48	-0.17	0.32	-0.33
	500	PC HC	0.71	0.66	-0.05	0.55	-0.16	0.41	-0.30
	1000	MMHC HC	0.60	0.54	-0.06	0.42	-0.19	0.24	-0.37
	1000	PC HC	0.65	0.60	-0.05	0.49	-0.17	0.32	-0.34

1500	MMHC HC	0.56	0.50	-0.06	0.37	-0.20	0.19	-0.37
1500	PC HC	0.63	0.57	-0.05	0.46	-0.17	0.28	-0.35
3000	MMHC HC	0.54	0.48	-0.06	0.33	-0.21	0.16	-0.38
3000	PC HC	0.61	0.55	-0.05	0.44	-0.17	0.25	-0.36

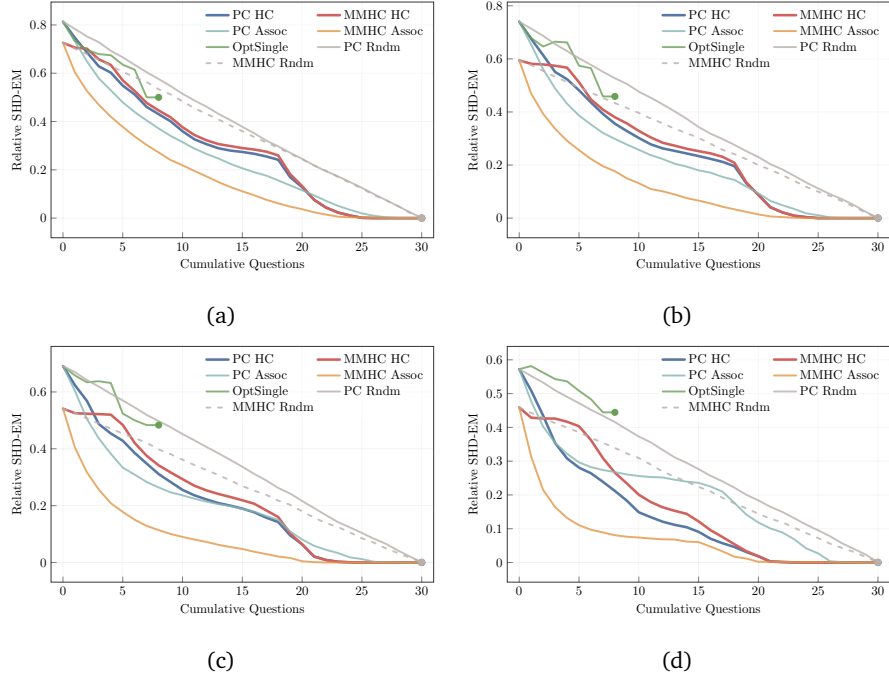


Figure 1: Survey DAG 6 nodes, 6 edges. (a) $N = 500$, (b) $N = 1000$, (c) $N = 1500$, (d) $N = 3000$.

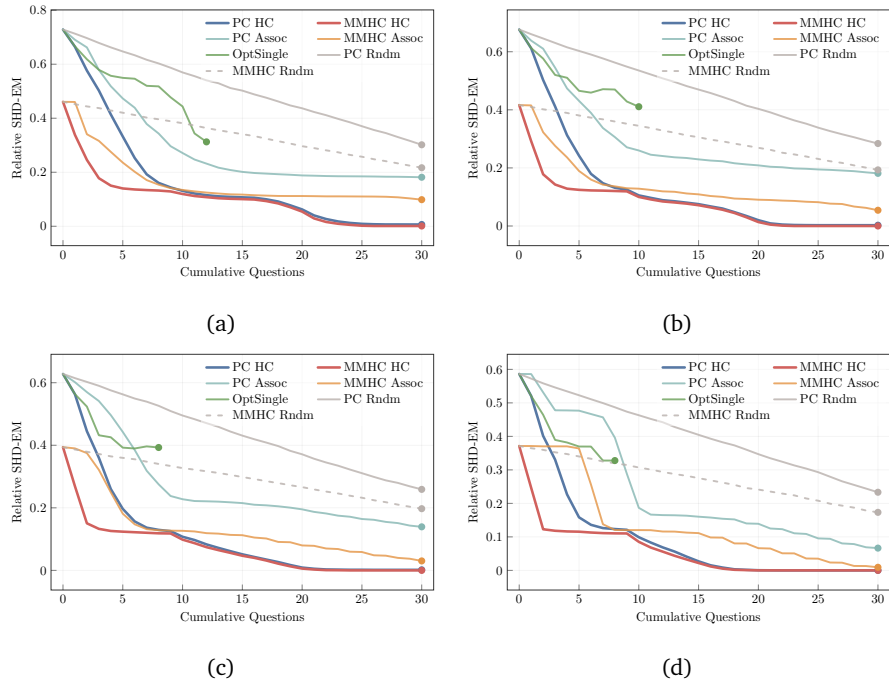


Figure 2: Asia DAG 8 nodes, 8 edges. (a) $N = 500$, (b) $N = 1000$, (c) $N = 1500$, (d) $N = 3000$.

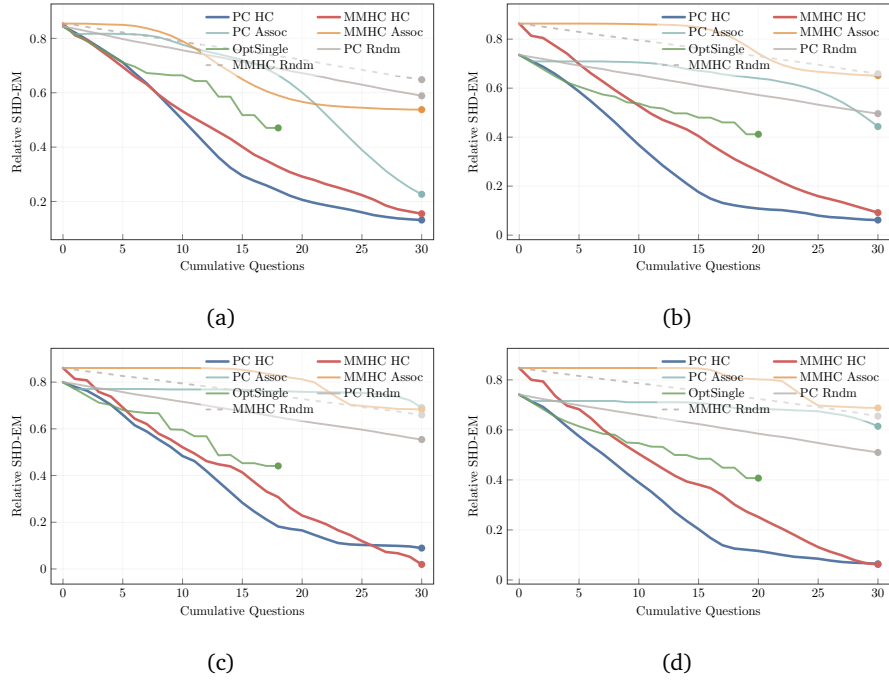


Figure 3: Sachs DAG 11 nodes, 17 edges (a) $N = 500$, (b) $N = 1000$, (c) $N = 1500$, (d) $N = 3000$.

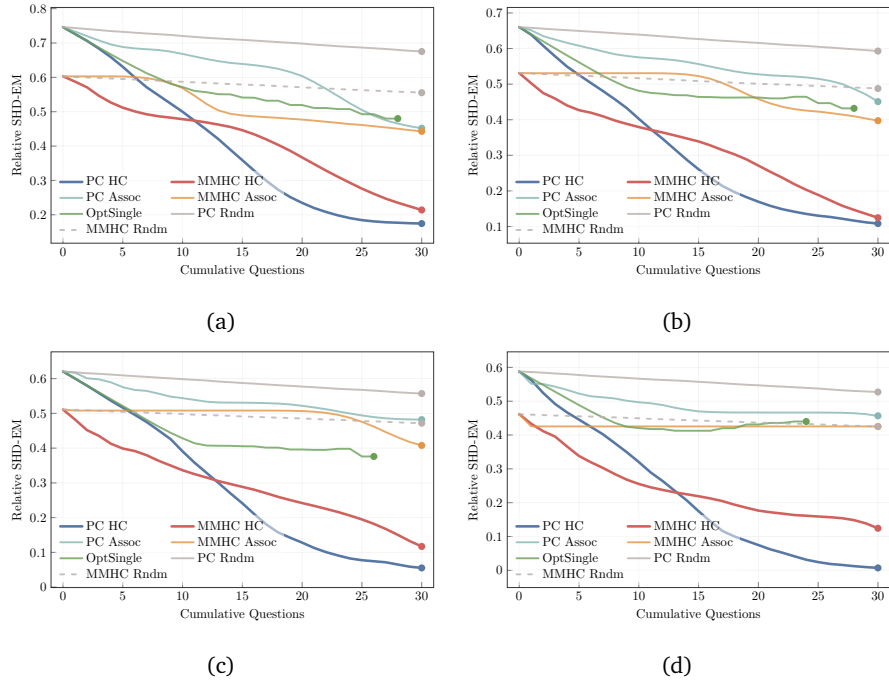


Figure 4: Child DAG 20 nodes, 25 edges. (a) $N = 500$, (b) $N = 1000$, (c) $N = 1500$, (d) $N = 3000$.

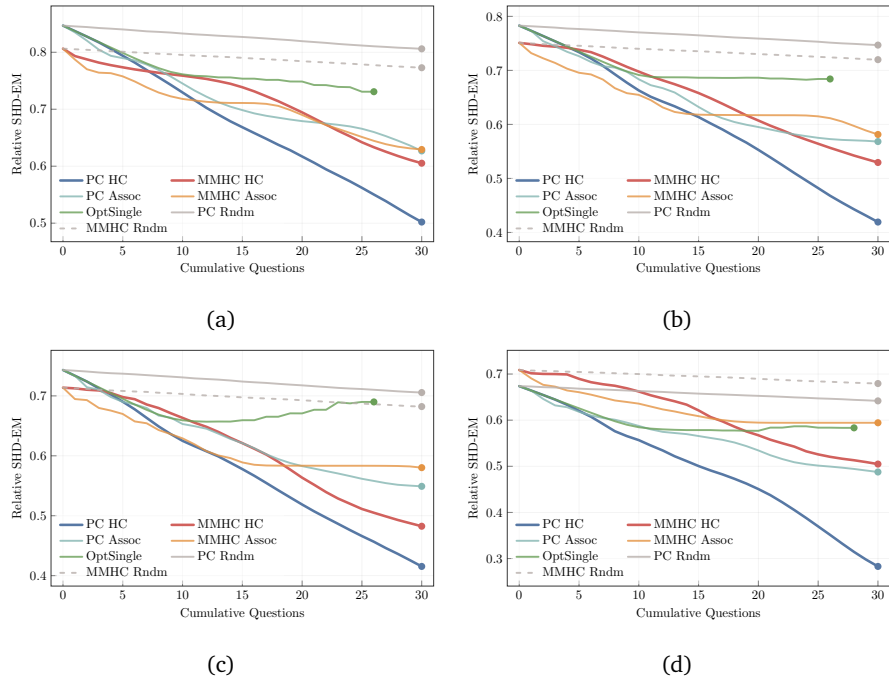


Figure 5: Insurance DAG 27 nodes, 52 edges. (a) $N = 500$, (b) $N = 1000$, (c) $N = 1500$, (d) $N = 3000$.

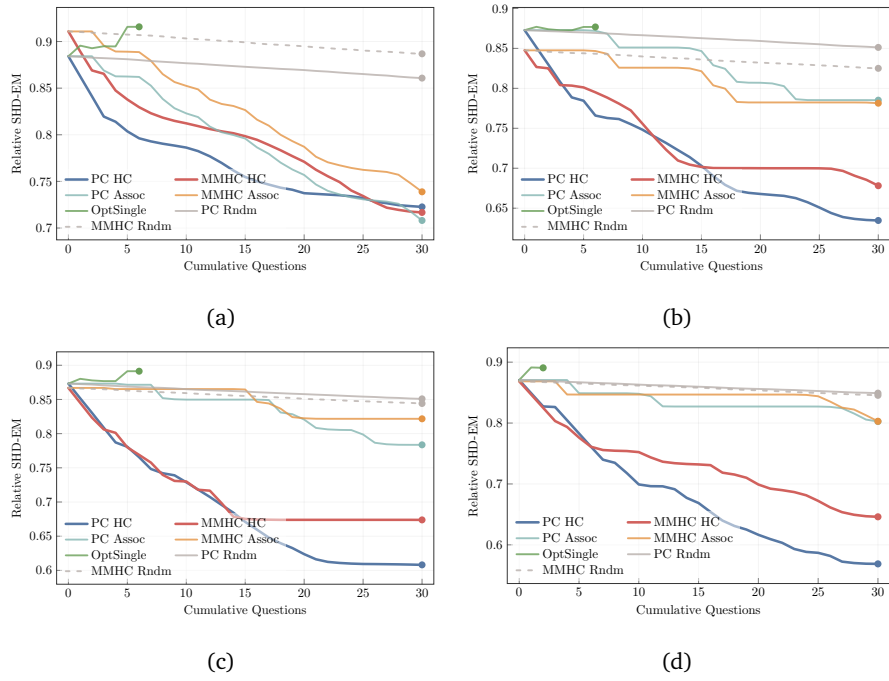


Figure 6: Mildew DAG 35 nodes, 46 edges. (a) $N = 500$, (b) $N = 1000$, (c) $N = 1500$, (d) $N = 3000$.

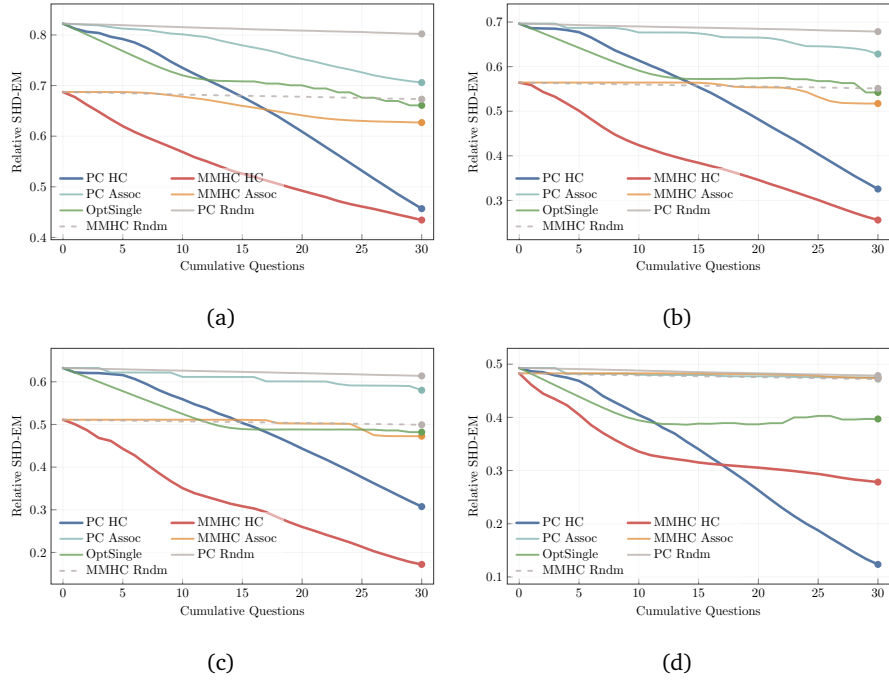


Figure 7: Alarm DAG, 37 nodes, 46 edges. (a) $N = 500$, (b) $N = 1000$, (c) $N = 1500$, (d) $N = 3000$.

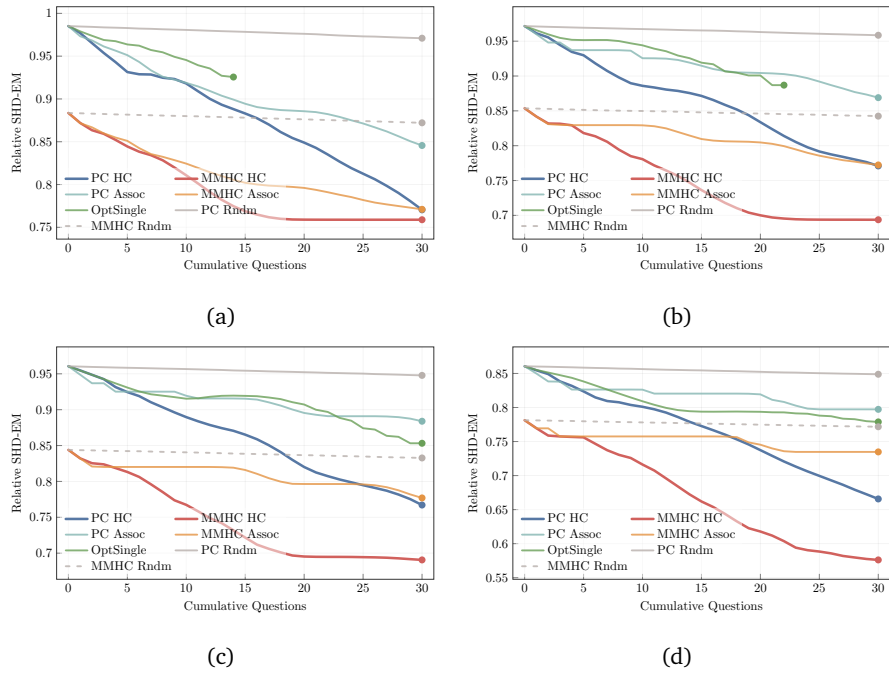


Figure 8: Barley DAG 48 nodes, 84 edges. (a) $N = 500$, (b) $N = 1000$, (c) $N = 1500$, (d) $N = 3000$, (e) $N = 5000$ (100 replicates).

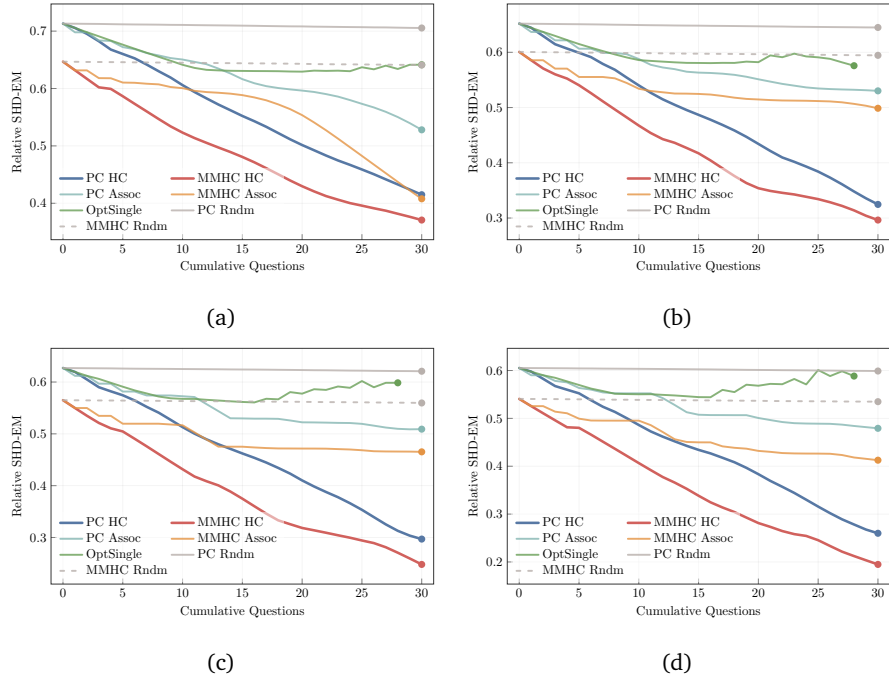


Figure 9: Hailfinder DAG 56 nodes, 66 edges. (a) $N = 500$, (b) $N = 1000$, (c) $N = 1500$, (d) $N = 3000$.