New Experiments

May 22, 2018

More Complex Instances

We consider the same instances as before, but we consider $K = 10$ instead of $K = 3$. Previously we had conjectured that increasing K only changes the time it takes to learn, but now we want to test if difficulty to learn the best arm can impact what happens in competition. Why would we think this should happen? There are two potentially counteracting effects one can think of:

1. Making the learning problem harder can benefit better algorithms in the long-run since they'll be more likely to identify the best arm than the worse algorithms and thus we expect there to be a bigger difference in the reputation scores between a good algorithm and a bad algorithm
2. Making the learning problem harder also forces the better algorithms to engage in more sub-optimal exploration which could have perverse short-run effects on reputation.

We summarize the results for each instance and comment on the difference from the $K = 3$ case:

1. Needle in Haystack:
   (a) HMR / SM: The results are roughly the same. $TS > DEG > DG$
   (b) HM: In $K = 3$, we had that the results were effectively 50/50 between TS and DEG/DG. However, with $K = 10$, we see that TS wins by a lot.
2. Uniform:
   (a) HMR/SM: The results are for the most part qualitatively the same. The one difference is that for $K = 10$ we see that $DEG > DG$ slightly more clearly.
   (b) HM: The results are also qualitatively similar, with no algorithm clearly dominating.
3. Heavy Tail:
   (a) HMR/SM: The results are starker than with $K = 3$ arms with TS dominating DEG and DG by a lot. However, we no longer see that $DG > DEG$ as we did in $K = 3$
   (b) HM: The results here are starker than with $K = 3$ arms, with DEG and DG dominating TS more than in the $K = 3$ case.

Results for t= 2000 Heavy Tail Memory= 100 K= 3

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.42** +/- 0.06 Var: 0.23 Share: 93 %	**0.45** +/- 0.06 Var: 0.24 Share: 96 %	**0.57** +/- 0.06 Var: 0.23 Share: 92 %			
HMR	**0.47** +/- 0.05 Var: 0.16 Share: 64 %	**0.44** +/- 0.05 Var: 0.17 Share: 70 %	**0.54** +/- 0.05 Var: 0.14 Share: 52 %			
SM	**0.57** +/- 0.02 Var: 0.035 Share: 3.2 %	**0.51** +/- 0.03 Var: 0.042 Share: 2.8 %	**0.53** +/- 0.03 Var: 0.053 Share: 4.4 %			

Results for t= 2000 Heavy Tail Memory= 100 K= 10

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.33** +/- 0.08 Var: 0.22 Share: 100 %	**0.37** +/- 0.08 Var: 0.23 Share: 100 %	**0.53** +/- 0.08 Var: 0.23 Share: 93 %			
HMR	**0.42** +/- 0.07 Var: 0.21 Share: 93 %	**0.42** +/- 0.07 Var: 0.18 Share: 77 %	**0.54** +/- 0.07 Var: 0.16 Share: 67 %			
SM	**0.6** +/- 0.04 Var: 0.053 Share: 4.7 %	**0.56** +/- 0.05 Var: 0.078 Share: 8 %	**0.52** +/- 0.04 Var: 0.058 Share: 6.7 %			

Results for t= 15000 Heavy Tail Memory= 100 K= 3

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.43** +/- 0.06 Var: 0.23 Share: 95 %	**0.47** +/- 0.06 Var: 0.24 Share: 95 %	**0.56** +/- 0.06 Var: 0.22 Share: 89 %			
HMR	**0.67** +/- 0.02 Var: 0.034 Share: 14 %	**0.55** +/- 0.03 Var: 0.053 Share: 16 %	**0.6** +/- 0.04 Var: 0.082 Share: 29 %			
SM	**0.6** +/- 0.01 Var: 0.0066 Share: 0 %	**0.56** +/- 0.02 Var: 0.022 Share: 0.4 %	**0.52** +/- 0.03 Var: 0.041 Share: 2.4 %			

Results for t= 15000 Heavy Tail Memory= 100 K= 10

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.33** +/- 0.08 Var: 0.22 Share: 100 %	**0.38** +/- 0.08 Var: 0.24 Share: 99 %	**0.52** +/- 0.08 Var: 0.24 Share: 95 %			
HMR	**0.74** +/- 0.03 Var: 0.044 Share: 33 %	**0.67** +/- 0.05 Var: 0.091 Share: 39 %	**0.48** +/- 0.06 Var: 0.12 Share: 38 %			
SM	**0.72** +/- 0.02 Var: 0.0094 Share: 0 %	**0.69** +/- 0.03 Var: 0.039 Share: 6.7 %	**0.44** +/- 0.04 Var: 0.068 Share: 3.3 %			

Results for t= 2000 Uniform Memory= 100 K= 3

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.5** +/- 0.06 Var: 0.23 Share: 93 %	**0.45** +/- 0.06 Var: 0.24 Share: 95 %	**0.5** +/- 0.06 Var: 0.23 Share: 90 %			
HMR	**0.48** +/- 0.05 Var: 0.14 Share: 51 %	**0.51** +/- 0.05 Var: 0.14 Share: 52 %	**0.5** +/- 0.04 Var: 0.12 Share: 40 %			
SM	**0.53** +/- 0.03 Var: 0.048 Share: 2 %	**0.52** +/- 0.03 Var: 0.054 Share: 2.4 %	**0.49** +/- 0.03 Var: 0.056 Share: 2.8 %			

Results for t= 2000 Uniform Memory= 100 K= 10

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.48** +/- 0.08 Var: 0.24 Share: 97 %	**0.5** +/- 0.08 Var: 0.25 Share: 98 %	**0.48** +/- 0.08 Var: 0.23 Share: 89 %			
HMR	**0.46** +/- 0.07 Var: 0.19 Share: 77 %	**0.47** +/- 0.07 Var: 0.17 Share: 72 %	**0.5** +/- 0.06 Var: 0.15 Share: 58 %			
SM	**0.43** +/- 0.04 Var: 0.074 Share: 3.3 %	**0.47** +/- 0.04 Var: 0.073 Share: 4.7 %	**0.49** +/- 0.04 Var: 0.053 Share: 2.7 %			

Results for t= 15000 Uniform Memory= 100 K= 3

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.52** +/- 0.06 Var: 0.22 Share: 88 %	**0.47** +/- 0.06 Var: 0.23 Share: 90 %	**0.47** +/- 0.06 Var: 0.23 Share: 89 %			
HMR	**0.56** +/- 0.02 Var: 0.036 Share: 7.2 %	**0.59** +/- 0.03 Var: 0.055 Share: 18 %	**0.48** +/- 0.03 Var: 0.067 Share: 19 %			
SM	**0.55** +/- 0.01 Var: 0.0088 Share: 0 %	**0.57** +/- 0.02 Var: 0.026 Share: 0.8 %	**0.45** +/- 0.02 Var: 0.035 Share: 0.8 %			

Results for t= 15000 Uniform Memory= 100 K= 10

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.49** +/- 0.08 Var: 0.25 Share: 99 %	**0.5** +/- 0.08 Var: 0.25 Share: 98 %	**0.44** +/- 0.08 Var: 0.22 Share: 91 %			
HMR	**0.54** +/- 0.04 Var: 0.075 Share: 21 %	**0.58** +/- 0.05 Var: 0.093 Share: 28 %	**0.43** +/- 0.05 Var: 0.097 Share: 32 %			
SM	**0.54** +/- 0.02 Var: 0.017 Share: 0 %	**0.61** +/- 0.03 Var: 0.036 Share: 2 %	**0.43** +/- 0.03 Var: 0.039 Share: 0.67 %			

Results for t= 2000 Needle In Haystack High Memory= 100 K= 3

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.52** +/- 0.06 Var: 0.24 Share: 96 %	**0.49** +/- 0.06 Var: 0.24 Share: 94 %	**0.43** +/- 0.06 Var: 0.23 Share: 92 %			
HMR	**0.48** +/- 0.05 Var: 0.16 Share: 62 %	**0.59** +/- 0.05 Var: 0.14 Share: 56 %	**0.48** +/- 0.05 Var: 0.15 Share: 58 %			
SM	**0.55** +/- 0.03 Var: 0.057 Share: 3.2 %	**0.53** +/- 0.03 Var: 0.063 Share: 2 %	**0.45** +/- 0.03 Var: 0.075 Share: 6.4 %			

Results for t= 2000 Needle In Haystack High Memory= 100 K= 10

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.64** +/- 0.08 Var: 0.22 Share: 95 %	**0.64** +/- 0.08 Var: 0.22 Share: 94 %	**0.44** +/- 0.08 Var: 0.23 Share: 90 %			
HMR	**0.59** +/- 0.07 Var: 0.19 Share: 79 %	**0.62** +/- 0.06 Var: 0.15 Share: 66 %	**0.45** +/- 0.06 Var: 0.13 Share: 47 %			
SM	**0.54** +/- 0.05 Var: 0.088 Share: 3.3 %	**0.6** +/- 0.05 Var: 0.082 Share: 5.3 %	**0.49** +/- 0.05 Var: 0.084 Share: 4 %			

Results for t= 15000 Needle In Haystack High Memory= 100 K= 3

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.54** +/- 0.06 Var: 0.24 Share: 94 %	**0.5** +/- 0.06 Var: 0.23 Share: 92 %	**0.42** +/- 0.06 Var: 0.23 Share: 92 %			
HMR	**0.57** +/- 0.02 Var: 0.04 Share: 11 %	**0.64** +/- 0.03 Var: 0.067 Share: 33 %	**0.44** +/- 0.04 Var: 0.09 Share: 34 %			
SM	**0.54** +/- 0.01 Var: 0.006 Share: 0 %	**0.59** +/- 0.02 Var: 0.034 Share: 0.8 %	**0.4** +/- 0.03 Var: 0.046 Share: 2 %			

Results for t= 15000 Needle In Haystack High Memory= 100 K= 10

	TS vs DEG	TS vs DG	DG vs DEG	TS vs TS	DEG vs DEG	DG vs DG
HM	**0.65** +/- 0.08 Var: 0.23 Share: 100 %	**0.67** +/- 0.07 Var: 0.21 Share: 97 %	**0.41** +/- 0.08 Var: 0.24 Share: 97 %			
HMR	**0.59** +/- 0.05 Var: 0.11 Share: 39 %	**0.66** +/- 0.06 Var: 0.12 Share: 55 %	**0.39** +/- 0.06 Var: 0.12 Share: 52 %			
SM	**0.59** +/- 0.03 Var: 0.031 Share: 0.67 %	**0.66** +/- 0.04 Var: 0.051 Share: 1.3 %	**0.42** +/- 0.05 Var: 0.083 Share: 1.3 %			

Information vs Reputation - Incumbent

The following tables contain three separate runs of the incumbent experiment (the realizations are different each time, but we should change this in future runs). The first is the one we have looked at before where one of the principals gets 200 free observations. In the second we artificially eliminate the reputation gain of the incumbent upon the entrant entering. In the third we artificially eliminate the information gain of the incumbent upon the entrant entering. Thus, the overall goal here is to ask what the effect reputation and information have individually as barriers to entry for learning.

Overall, the results are as follows:

1. The effect of reputation in HardMax seems to be relatively large for the incumbent. Looking at the Info table with the HardMax response function shows that the entrant gets a significant amount of the market back when the reputation gain is erased. When the information gain is erased, with HardMax the incumbent doesn't lose much market share. It appears somewhat similar in HardMaxWithRandom, but the difference is not so stark.

2. I am not sure what to make of the SoftMax case. It seems that losing reputation and information can actually *benefit* the incumbent. I can't think of why this would make any sense, so I'm going to rerun these again using the same realizations. I did not record the parametrization for SoftMax during each of the runs, so it is possible that this is why we see these results. As a result, take the SoftMax results with a grain of salt until I re-run this.

Results for HardMax t = 1000 Needle In Haystack High Info + Rep

	Thompson Sampling	Dynamic Epsilon Greedy	DynamicGreedy
Thompson Sampling	**0.1** +/- 0.022 0.063 (0.056, 0.072) Extreme Shares: 87 %	**0.13** +/- 0.026 0.086 (0.076, 0.097) Extreme Shares: 88 %	**0.28** +/- 0.036 0.17 (0.15, 0.19) Extreme Shares: 84 %
Dynamic Epsilon Greedy	**0.093** +/- 0.022 0.064 (0.056, 0.072) Extreme Shares: 91 %	**0.18** +/- 0.031 0.12 (0.11, 0.14) Extreme Shares: 89 %	**0.26** +/- 0.035 0.16 (0.14, 0.18) Extreme Shares: 86 %
DynamicGreedy	**0.11** +/- 0.024 0.072 (0.064, 0.081) Extreme Shares: 87 %	**0.18** +/- 0.03 0.12 (0.1, 0.13) Extreme Shares: 88 %	**0.23** +/- 0.033 0.14 (0.13, 0.16) Extreme Shares: 85 %

Results for HardMax t = 1000 Needle In Haystack High Info

	Thompson Sampling	Dynamic Epsilon Greedy	DynamicGreedy
Thompson Sampling	**0.32** +/- 0.051 0.2 (0.17, 0.24) Extreme Shares: 94 %	**0.35** +/- 0.052 0.21 (0.18, 0.25) Extreme Shares: 92 %	**0.46** +/- 0.055 0.23 (0.2, 0.28) Extreme Shares: 94 %
Dynamic Epsilon Greedy	**0.26** +/- 0.048 0.18 (0.15, 0.21) Extreme Shares: 93 %	**0.37** +/- 0.053 0.22 (0.18, 0.25) Extreme Shares: 92 %	**0.41** +/- 0.053 0.22 (0.19, 0.26) Extreme Shares: 90 %
DynamicGreedy	**0.29** +/- 0.049 0.19 (0.16, 0.22) Extreme Shares: 94 %	**0.32** +/- 0.051 0.2 (0.17, 0.24) Extreme Shares: 92 %	**0.4** +/- 0.053 0.22 (0.19, 0.26) Extreme Shares: 89 %

Results for HardMax t = 1000 Needle In Haystack High Rep

	Thompson Sampling	Dynamic Epsilon Greedy	DynamicGreedy
Thompson Sampling	**0.15** +/- 0.037 0.11 (0.091, 0.13) Extreme Shares: 90 %	**0.25** +/- 0.045 0.16 (0.13, 0.19) Extreme Shares: 88 %	**0.32** +/- 0.049 0.19 (0.16, 0.22) Extreme Shares: 86 %
Dynamic Epsilon Greedy	**0.16** +/- 0.037 0.11 (0.091, 0.12) Extreme Shares: 88 %	**0.24** +/- 0.045 0.15 (0.13, 0.18) Extreme Shares: 89 %	**0.29** +/- 0.046 0.16 (0.14, 0.19) Extreme Shares: 80 %
DynamicGreedy	**0.16** +/- 0.038 0.11 (0.096, 0.13) Extreme Shares: 91 %	**0.21** +/- 0.042 0.14 (0.12, 0.16) Extreme Shares: 86 %	**0.31** +/- 0.048 0.18 (0.15, 0.21) Extreme Shares: 83 %

Results for HardMaxWithRandom t = 1000 Needle In Haystack High Info + Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.17** +/- 0.023 0.067 (0.059, 0.076) Extreme Shares: 73 %	**0.3** +/- 0.031 0.13 (0.11, 0.14) Extreme Shares: 66 %	**0.34** +/- 0.034 0.15 (0.13, 0.17) Extreme Shares: 71 %
Dynamic Epsilon Greedy	**0.22** +/- 0.026 0.088 (0.078, 0.1) Extreme Shares: 67 %	**0.26** +/- 0.029 0.11 (0.094, 0.12) Extreme Shares: 68 %	**0.37** +/- 0.034 0.15 (0.13, 0.17) Extreme Shares: 66 %
DynamicGreedy	**0.23** +/- 0.026 0.086 (0.076, 0.097) Extreme Shares: 65 %	**0.29** +/- 0.03 0.12 (0.1, 0.13) Extreme Shares: 65 %	**0.37** +/- 0.033 0.14 (0.12, 0.16) Extreme Shares: 63 %

Results for HardMaxWithRandom t = 1000 Needle In Haystack High Info

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.31** +/- 0.041 0.13 (0.11, 0.16) Extreme Shares: 68 %	**0.36** +/- 0.045 0.16 (0.13, 0.19) Extreme Shares: 70 %	**0.47** +/- 0.047 0.17 (0.15, 0.21) Extreme Shares: 70 %
Dynamic Epsilon Greedy	**0.31** +/- 0.041 0.13 (0.11, 0.15) Extreme Shares: 69 %	**0.38** +/- 0.045 0.16 (0.13, 0.19) Extreme Shares: 71 %	**0.51** +/- 0.047 0.17 (0.14, 0.2) Extreme Shares: 68 %
DynamicGreedy	**0.3** +/- 0.041 0.13 (0.11, 0.15) Extreme Shares: 70 %	**0.34** +/- 0.043 0.14 (0.12, 0.17) Extreme Shares: 69 %	**0.45** +/- 0.045 0.16 (0.14, 0.19) Extreme Shares: 64 %

Results for HardMaxWithRandom t = 1000 Needle In Haystack High Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.25** +/- 0.036 0.1 (0.087, 0.12) Extreme Shares: 65 %	**0.33** +/- 0.043 0.14 (0.12, 0.17) Extreme Shares: 69 %	**0.41** +/- 0.046 0.16 (0.14, 0.19) Extreme Shares: 67 %
Dynamic Epsilon Greedy	**0.24** +/- 0.036 0.1 (0.087, 0.12) Extreme Shares: 69 %	**0.36** +/- 0.042 0.14 (0.12, 0.16) Extreme Shares: 60 %	**0.4** +/- 0.044 0.15 (0.13, 0.18) Extreme Shares: 63 %
DynamicGreedy	**0.23** +/- 0.036 0.099 (0.085, 0.12) Extreme Shares: 70 %	**0.3** +/- 0.041 0.13 (0.11, 0.15) Extreme Shares: 67 %	**0.39** +/- 0.043 0.14 (0.12, 0.17) Extreme Shares: 59 %

Results for SoftMax t = 1000 Needle In Haystack High Info + Rep

	Thompson Sampling	Dynamic Epsilon Greedy	DynamicGreedy
Thompson Sampling	**0.43** +/- 0.0082 0.0088 (0.0078, 0.01) Extreme Shares: 0 %	**0.46** +/- 0.012 0.018 (0.016, 0.02) Extreme Shares: 0 %	**0.52** +/- 0.016 0.033 (0.029, 0.037) Extreme Shares: 0 %
Dynamic Epsilon Greedy	**0.42** +/- 0.011 0.016 (0.014, 0.018) Extreme Shares: 0 %	**0.46** +/- 0.013 0.023 (0.021, 0.027) Extreme Shares: 0 %	**0.5** +/- 0.017 0.036 (0.032, 0.041) Extreme Shares: 0 %
DynamicGreedy	**0.39** +/- 0.013 0.022 (0.02, 0.025) Extreme Shares: 0 %	**0.44** +/- 0.015 0.03 (0.026, 0.034) Extreme Shares: 0 %	**0.49** +/- 0.017 0.039 (0.034, 0.044) Extreme Shares: 0 %

Results for SoftMax t = 1000 Needle In Haystack High Info

	Thompson Sampling	Dynamic Epsilon Greedy	DynamicGreedy
Thompson Sampling	**0.33** +/- 0.025 0.05 (0.043, 0.059) Extreme Shares: 6.3 %	**0.39** +/- 0.03 0.069 (0.059, 0.082) Extreme Shares: 7.3 %	**0.48** +/- 0.036 0.099 (0.085, 0.12) Extreme Shares: 13 %
Dynamic Epsilon Greedy	**0.34** +/- 0.027 0.057 (0.049, 0.067) Extreme Shares: 12 %	**0.4** +/- 0.032 0.078 (0.067, 0.092) Extreme Shares: 14 %	**0.47** +/- 0.034 0.09 (0.077, 0.11) Extreme Shares: 12 %
DynamicGreedy	**0.37** +/- 0.029 0.066 (0.057, 0.079) Extreme Shares: 11 %	**0.38** +/- 0.031 0.072 (0.062, 0.085) Extreme Shares: 15 %	**0.45** +/- 0.033 0.085 (0.073, 0.1) Extreme Shares: 12 %

Results for SoftMax t = 1000 Needle In Haystack High Rep

	Thompson Sampling	Dynamic Epsilon Greedy	DynamicGreedy
Thompson Sampling	**0.39** +/- 0.029 0.066 (0.056, 0.078) Extreme Shares: 8.7 %	**0.47** +/- 0.032 0.081 (0.069, 0.095) Extreme Shares: 4 %	**0.5** +/- 0.035 0.093 (0.079, 0.11) Extreme Shares: 10 %
Dynamic Epsilon Greedy	**0.39** +/- 0.031 0.075 (0.064, 0.089) Extreme Shares: 14 %	**0.46** +/- 0.032 0.08 (0.069, 0.095) Extreme Shares: 9.3 %	**0.5** +/- 0.033 0.084 (0.072, 0.099) Extreme Shares: 11 %
DynamicGreedy	**0.39** +/- 0.032 0.079 (0.068, 0.093) Extreme Shares: 11 %	**0.39** +/- 0.032 0.079 (0.068, 0.093) Extreme Shares: 11 %	**0.49** +/- 0.033 0.086 (0.074, 0.1) Extreme Shares: 7.7 %

Results for HardMax t = 1000 Heavy Tail Info + Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.042** +/- 0.014 0.026 (0.023, 0.03) Extreme Shares: 93 %	**0.081** +/- 0.021 0.06 (0.053, 0.068) Extreme Shares: 93 %	**0.12** +/- 0.027 0.091 (0.081, 0.1) Extreme Shares: 93 %
Dynamic Epsilon Greedy	**0.11** +/- 0.022 0.062 (0.055, 0.071) Extreme Shares: 84 %	**0.15** +/- 0.026 0.087 (0.077, 0.099) Extreme Shares: 81 %	**0.16** +/- 0.028 0.099 (0.088, 0.11) Extreme Shares: 83 %
DynamicGreedy	**0.14** +/- 0.024 0.077 (0.068, 0.088) Extreme Shares: 82 %	**0.2** +/- 0.031 0.13 (0.11, 0.14) Extreme Shares: 83 %	**0.18** +/- 0.027 0.097 (0.086, 0.11) Extreme Shares: 76 %

Results for HardMax t = 1000 Heavy Tail Info

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.18** +/- 0.042 0.14 (0.12, 0.16) Extreme Shares: 97 %	**0.17** +/- 0.042 0.14 (0.12, 0.16) Extreme Shares: 98 %	**0.23** +/- 0.047 0.17 (0.15, 0.2) Extreme Shares: 98 %
Dynamic Epsilon Greedy	**0.23** +/- 0.045 0.16 (0.13, 0.19) Extreme Shares: 92 %	**0.32** +/- 0.049 0.19 (0.16, 0.22) Extreme Shares: 86 %	**0.25** +/- 0.046 0.16 (0.14, 0.19) Extreme Shares: 90 %
DynamicGreedy	**0.28** +/- 0.047 0.17 (0.15, 0.2) Extreme Shares: 87 %	**0.33** +/- 0.051 0.2 (0.17, 0.23) Extreme Shares: 91 %	**0.3** +/- 0.047 0.17 (0.15, 0.2) Extreme Shares: 83 %

Results for HardMax t = 1000 Heavy Tail Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.059** +/- 0.025 0.047 (0.04, 0.056) Extreme Shares: 97 %	**0.11** +/- 0.033 0.085 (0.073, 0.1) Extreme Shares: 94 %	**0.15** +/- 0.038 0.11 (0.097, 0.13) Extreme Shares: 92 %
Dynamic Epsilon Greedy	**0.11** +/- 0.031 0.076 (0.066, 0.09) Extreme Shares: 89 %	**0.19** +/- 0.038 0.11 (0.095, 0.13) Extreme Shares: 82 %	**0.18** +/- 0.038 0.11 (0.094, 0.13) Extreme Shares: 82 %
DynamicGreedy	**0.17** +/- 0.038 0.11 (0.097, 0.13) Extreme Shares: 87 %	**0.22** +/- 0.042 0.13 (0.11, 0.16) Extreme Shares: 82 %	**0.26** +/- 0.043 0.14 (0.12, 0.17) Extreme Shares: 77 %

Results for HardMaxWithRandom t = 1000 Heavy Tail Info + Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.12** +/- 0.018 0.042 (0.037, 0.048) Extreme Shares: 80 %	**0.17** +/- 0.024 0.073 (0.065, 0.083) Extreme Shares: 75 %	**0.21** +/- 0.028 0.1 (0.092, 0.12) Extreme Shares: 76 %
Dynamic Epsilon Greedy	**0.17** +/- 0.021 0.055 (0.049, 0.063) Extreme Shares: 67 %	**0.27** +/- 0.026 0.09 (0.08, 0.1) Extreme Shares: 54 %	**0.25** +/- 0.027 0.095 (0.084, 0.11) Extreme Shares: 62 %
DynamicGreedy	**0.21** +/- 0.024 0.077 (0.068, 0.087) Extreme Shares: 63 %	**0.31** +/- 0.029 0.11 (0.096, 0.12) Extreme Shares: 55 %	**0.3** +/- 0.028 0.1 (0.091, 0.12) Extreme Shares: 54 %

Results for HardMaxWithRandom t = 1000 Heavy Tail Info

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.15** +/- 0.031 0.074 (0.063, 0.087) Extreme Shares: 85 %	**0.24** +/- 0.039 0.12 (0.1, 0.14) Extreme Shares: 75 %	**0.28** +/- 0.042 0.14 (0.12, 0.16) Extreme Shares: 79 %
Dynamic Epsilon Greedy	**0.23** +/- 0.035 0.093 (0.08, 0.11) Extreme Shares: 68 %	**0.34** +/- 0.042 0.13 (0.12, 0.16) Extreme Shares: 63 %	**0.29** +/- 0.04 0.12 (0.11, 0.15) Extreme Shares: 67 %
DynamicGreedy	**0.3** +/- 0.039 0.12 (0.1, 0.14) Extreme Shares: 66 %	**0.38** +/- 0.044 0.15 (0.13, 0.18) Extreme Shares: 66 %	**0.34** +/- 0.04 0.13 (0.11, 0.15) Extreme Shares: 59 %

Results for HardMaxWithRandom t = 1000 Heavy Tail Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.14** +/- 0.027 0.057 (0.049, 0.068) Extreme Shares: 77 %	**0.22** +/- 0.034 0.091 (0.078, 0.11) Extreme Shares: 69 %	**0.25** +/- 0.039 0.12 (0.1, 0.14) Extreme Shares: 75 %
Dynamic Epsilon Greedy	**0.22** +/- 0.034 0.09 (0.077, 0.11) Extreme Shares: 69 %	**0.32** +/- 0.038 0.11 (0.095, 0.13) Extreme Shares: 52 %	**0.3** +/- 0.038 0.11 (0.096, 0.13) Extreme Shares: 58 %
DynamicGreedy	**0.26** +/- 0.039 0.12 (0.1, 0.14) Extreme Shares: 71 %	**0.4** +/- 0.042 0.14 (0.12, 0.16) Extreme Shares: 55 %	**0.34** +/- 0.038 0.11 (0.098, 0.14) Extreme Shares: 54 %

Results for SoftMax t = 1000 Heavy Tail Info + Rep

	Thompson Sampling	Dynamic Epsilon Greedy	DynamicGreedy
Thompson Sampling	**0.44** +/- 0.0059 0.0045 (0.004, 0.0052) Extreme Shares: 0 %	**0.48** +/- 0.0083 0.009 (0.008, 0.01) Extreme Shares: 0 %	**0.48** +/- 0.011 0.015 (0.013, 0.017) Extreme Shares: 0 %
Dynamic Epsilon Greedy	**0.43** +/- 0.0084 0.0092 (0.0081, 0.01) Extreme Shares: 0 %	**0.46** +/- 0.0087 0.0098 (0.0087, 0.011) Extreme Shares: 0 %	**0.47** +/- 0.012 0.018 (0.016, 0.021) Extreme Shares: 0 %
DynamicGreedy	**0.44** +/- 0.0099 0.013 (0.011, 0.014) Extreme Shares: 0.2 %	**0.47** +/- 0.011 0.016 (0.014, 0.018) Extreme Shares: 0.2 %	**0.49** +/- 0.011 0.015 (0.014, 0.017) Extreme Shares: 0 %

Results for SoftMax t = 1000 Heavy Tail Info

	Thompson Sampling	Dynamic Epsilon Greedy	DynamicGreedy
Thompson Sampling	**0.32** +/- 0.02 0.032 (0.027, 0.038) Extreme Shares: 3 %	**0.45** +/- 0.026 0.052 (0.045, 0.062) Extreme Shares: 4.3 %	**0.4** +/- 0.028 0.061 (0.052, 0.072) Extreme Shares: 10 %
Dynamic Epsilon Greedy	**0.33** +/- 0.023 0.042 (0.036, 0.05) Extreme Shares: 6 %	**0.42** +/- 0.025 0.049 (0.042, 0.058) Extreme Shares: 5.3 %	**0.38** +/- 0.027 0.056 (0.048, 0.066) Extreme Shares: 7.3 %
DynamicGreedy	**0.4** +/- 0.023 0.042 (0.036, 0.05) Extreme Shares: 5.7 %	**0.48** +/- 0.026 0.054 (0.046, 0.063) Extreme Shares: 3.7 %	**0.45** +/- 0.025 0.048 (0.041, 0.057) Extreme Shares: 6.3 %

Results for SoftMax t = 1000 Heavy Tail Rep

	Thompson Sampling	Dynamic Epsilon Greedy	DynamicGreedy
Thompson Sampling	**0.35** +/- 0.022 0.039 (0.033, 0.046) Extreme Shares: 5 %	**0.47** +/- 0.028 0.059 (0.051, 0.07) Extreme Shares: 5.7 %	**0.43** +/- 0.029 0.064 (0.055, 0.075) Extreme Shares: 4 %
Dynamic Epsilon Greedy	**0.35** +/- 0.025 0.048 (0.041, 0.057) Extreme Shares: 6 %	**0.43** +/- 0.026 0.053 (0.045, 0.062) Extreme Shares: 6 %	**0.41** +/- 0.026 0.054 (0.046, 0.063) Extreme Shares: 4.3 %
DynamicGreedy	**0.42** +/- 0.027 0.057 (0.049, 0.068) Extreme Shares: 8.3 %	**0.49** +/- 0.027 0.055 (0.047, 0.065) Extreme Shares: 4.3 %	**0.47** +/- 0.025 0.049 (0.042, 0.058) Extreme Shares: 5.7 %

Results for HardMax t = 1000 Uniform Info + Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.092** +/- 0.02 0.053 (0.047, 0.06) Extreme Shares: 86 %	**0.14** +/- 0.026 0.089 (0.079, 0.1) Extreme Shares: 84 %	**0.19** +/- 0.03 0.11 (0.1, 0.13) Extreme Shares: 81 %
Dynamic Epsilon Greedy	**0.16** +/- 0.026 0.089 (0.079, 0.1) Extreme Shares: 80 %	**0.18** +/- 0.028 0.1 (0.089, 0.11) Extreme Shares: 76 %	**0.19** +/- 0.03 0.12 (0.1, 0.13) Extreme Shares: 82 %
DynamicGreedy	**0.18** +/- 0.029 0.11 (0.095, 0.12) Extreme Shares: 81 %	**0.19** +/- 0.029 0.11 (0.099, 0.13) Extreme Shares: 79 %	**0.23** +/- 0.031 0.12 (0.11, 0.14) Extreme Shares: 75 %

Results for HardMax t = 1000 Uniform Info

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.33** +/- 0.051 0.21 (0.18, 0.24) Extreme Shares: 94 %	**0.38** +/- 0.053 0.22 (0.19, 0.26) Extreme Shares: 92 %	**0.36** +/- 0.052 0.21 (0.18, 0.25) Extreme Shares: 90 %
Dynamic Epsilon Greedy	**0.36** +/- 0.051 0.2 (0.17, 0.24) Extreme Shares: 86 %	**0.44** +/- 0.053 0.22 (0.19, 0.26) Extreme Shares: 88 %	**0.41** +/- 0.052 0.21 (0.18, 0.24) Extreme Shares: 83 %
DynamicGreedy	**0.38** +/- 0.052 0.21 (0.18, 0.25) Extreme Shares: 88 %	**0.39** +/- 0.052 0.21 (0.18, 0.25) Extreme Shares: 87 %	**0.43** +/- 0.054 0.22 (0.19, 0.26) Extreme Shares: 91 %

Results for HardMax t = 1000 Uniform Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.13** +/- 0.032 0.081 (0.069, 0.095) Extreme Shares: 84 %	**0.22** +/- 0.041 0.13 (0.11, 0.15) Extreme Shares: 81 %	**0.21** +/- 0.042 0.14 (0.12, 0.16) Extreme Shares: 86 %
Dynamic Epsilon Greedy	**0.18** +/- 0.038 0.11 (0.096, 0.13) Extreme Shares: 83 %	**0.22** +/- 0.04 0.13 (0.11, 0.15) Extreme Shares: 78 %	**0.23** +/- 0.041 0.13 (0.11, 0.16) Extreme Shares: 79 %
DynamicGreedy	**0.19** +/- 0.039 0.12 (0.1, 0.14) Extreme Shares: 84 %	**0.25** +/- 0.041 0.13 (0.11, 0.16) Extreme Shares: 73 %	**0.24** +/- 0.043 0.14 (0.12, 0.17) Extreme Shares: 81 %

Results for HardMaxWithRandom t = 1000 Uniform Info + Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.22** +/- 0.024 0.076 (0.067, 0.086) Extreme Shares: 60 %	**0.27** +/- 0.028 0.1 (0.091, 0.12) Extreme Shares: 61 %	**0.31** +/- 0.031 0.12 (0.11, 0.14) Extreme Shares: 61 %
Dynamic Epsilon Greedy	**0.27** +/- 0.026 0.088 (0.078, 0.1) Extreme Shares: 54 %	**0.3** +/- 0.028 0.1 (0.091, 0.12) Extreme Shares: 54 %	**0.35** +/- 0.03 0.12 (0.11, 0.14) Extreme Shares: 53 %
DynamicGreedy	**0.25** +/- 0.026 0.086 (0.076, 0.098) Extreme Shares: 59 %	**0.32** +/- 0.029 0.11 (0.099, 0.13) Extreme Shares: 55 %	**0.36** +/- 0.03 0.12 (0.11, 0.14) Extreme Shares: 52 %

Results for HardMaxWithRandom t = 1000 Uniform Info

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.3** +/- 0.04 0.12 (0.11, 0.15) Extreme Shares: 64 %	**0.39** +/- 0.043 0.15 (0.12, 0.17) Extreme Shares: 63 %	**0.42** +/- 0.044 0.15 (0.13, 0.18) Extreme Shares: 61 %
Dynamic Epsilon Greedy	**0.36** +/- 0.041 0.13 (0.11, 0.15) Extreme Shares: 57 %	**0.41** +/- 0.041 0.13 (0.11, 0.15) Extreme Shares: 52 %	**0.46** +/- 0.043 0.15 (0.13, 0.17) Extreme Shares: 56 %
DynamicGreedy	**0.36** +/- 0.041 0.13 (0.11, 0.16) Extreme Shares: 58 %	**0.44** +/- 0.043 0.14 (0.12, 0.17) Extreme Shares: 57 %	**0.42** +/- 0.043 0.14 (0.12, 0.17) Extreme Shares: 58 %

Results for HardMaxWithRandom t = 1000 Uniform Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.28** +/- 0.036 0.1 (0.086, 0.12) Extreme Shares: 56 %	**0.29** +/- 0.038 0.11 (0.095, 0.13) Extreme Shares: 59 %	**0.38** +/- 0.042 0.13 (0.12, 0.16) Extreme Shares: 58 %
Dynamic Epsilon Greedy	**0.27** +/- 0.036 0.1 (0.088, 0.12) Extreme Shares: 58 %	**0.31** +/- 0.037 0.11 (0.093, 0.13) Extreme Shares: 55 %	**0.37** +/- 0.041 0.13 (0.11, 0.15) Extreme Shares: 56 %
DynamicGreedy	**0.34** +/- 0.04 0.12 (0.11, 0.15) Extreme Shares: 58 %	**0.31** +/- 0.037 0.11 (0.09, 0.12) Extreme Shares: 53 %	**0.38** +/- 0.041 0.13 (0.11, 0.15) Extreme Shares: 56 %

Results for SoftMax t = 1000 Uniform Info + Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.45** +/- 0.0084 0.0091 (0.0081, 0.01) Extreme Shares: 0 %	**0.47** +/- 0.0099 0.013 (0.011, 0.014) Extreme Shares: 0 %	**0.51** +/- 0.013 0.021 (0.018, 0.024) Extreme Shares: 0 %
Dynamic Epsilon Greedy	**0.44** +/- 0.01 0.013 (0.012, 0.015) Extreme Shares: 0 %	**0.46** +/- 0.011 0.016 (0.014, 0.018) Extreme Shares: 0 %	**0.49** +/- 0.014 0.024 (0.021, 0.027) Extreme Shares: 0.2 %
DynamicGreedy	**0.43** +/- 0.011 0.017 (0.015, 0.019) Extreme Shares: 0 %	**0.46** +/- 0.012 0.019 (0.017, 0.021) Extreme Shares: 0 %	**0.49** +/- 0.013 0.022 (0.02, 0.025) Extreme Shares: 0.2 %

Results for SoftMax t = 1000 Uniform Info

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.37** +/- 0.026 0.051 (0.044, 0.06) Extreme Shares: 5.7 %	**0.42** +/- 0.029 0.064 (0.055, 0.076) Extreme Shares: 5.3 %	**0.45** +/- 0.031 0.074 (0.063, 0.087) Extreme Shares: 8 %
Dynamic Epsilon Greedy	**0.41** +/- 0.027 0.054 (0.047, 0.064) Extreme Shares: 6.3 %	**0.45** +/- 0.028 0.062 (0.053, 0.073) Extreme Shares: 5.3 %	**0.47** +/- 0.029 0.063 (0.054, 0.075) Extreme Shares: 4.3 %
DynamicGreedy	**0.43** +/- 0.027 0.055 (0.047, 0.064) Extreme Shares: 5.3 %	**0.44** +/- 0.027 0.058 (0.05, 0.068) Extreme Shares: 6.7 %	**0.45** +/- 0.03 0.069 (0.059, 0.081) Extreme Shares: 8 %

Results for SoftMax t = 1000 Uniform Rep

	Thompson Sampling	**Dynamic Epsilon Greedy**	**DynamicGreedy**
Thompson Sampling	**0.42** +/- 0.027 0.056 (0.048, 0.066) Extreme Shares: 3 %	**0.45** +/- 0.027 0.058 (0.05, 0.069) Extreme Shares: 2 %	**0.46** +/- 0.03 0.068 (0.059, 0.081) Extreme Shares: 5.7 %
Dynamic Epsilon Greedy	**0.43** +/- 0.027 0.056 (0.048, 0.066) Extreme Shares: 5.3 %	**0.47** +/- 0.028 0.063 (0.054, 0.074) Extreme Shares: 5 %	**0.46** +/- 0.029 0.066 (0.056, 0.077) Extreme Shares: 3.7 %
DynamicGreedy	**0.44** +/- 0.029 0.064 (0.055, 0.076) Extreme Shares: 7.7 %	**0.45** +/- 0.028 0.059 (0.051, 0.07) Extreme Shares: 4 %	**0.46** +/- 0.029 0.064 (0.055, 0.076) Extreme Shares: 5.3 %