**Behavioral Data**

* Toss criteria: Dropping any subject w/ numTrialsCompleted < 200 or > 250.
* Analyzed with R.
* model=glmer(Choice~MFonMB+(1|Subj)+(0+MFonMB|Subj),family=binomial,data=data\_crits);model\_all=glmer(Choice~MB+MF+MFonMB+(1|Subj)+(0+MB+MF+MFonMB|Subj),family=binomial,data=data\_crits)  
  model\_unlikely=glmer(Choice~Unlikely+(1|Subj)+(0+Unlikely|Subj),family=binomial,data=data\_unlikely)
* MB and MF in model\_all have no distance cutoff, but are time-discounted (gamma = .85)

***Baseline***

t-test: 135 subjects, 3806 observations  
model: 7 dropped

**model:**

Converged  
MFonMB estimate = 0.191  
Wald z-test: SE = 0.016, z = 12.1, p < 2e-16  
LRT: Chisq = 266.0, df = 2, p < 2.2e-16  
Bootstrapping: ???

**model\_all:**

Converged  
MFonMB estimate = 0.200 (z = 12.3, p < 2e-16)  
MB estimate = 0.221 (z = 7.3, p = 2.82e-13)  
MF estimate = 0.0543 (z = 1.87, p = 0.0621)   
LRT: Chisq = 298.2, df = 4, p < 2.2e-16  
Bootstrapping: ???

**t-test:**

Means: 0.89476980 0.01085237 0.68624149 0.01672222  
t = -12.5377, df = 134, p-value < 2.2e-16

***2-trial-type***

t-test: 303 subjects, 4231 congruent observations, 2137 incongruent observations  
model: dropped 2

**model:**

MFonMB estimate = 0.056 (z = 4.51, p < .0001).  
LRT: Chisq = 27.8, df = 2, p < .0001  
Bootstrapping: ???

**model\_incog:**

Converged  
MFonMB estimate = .009 (z = .784, p = 0.433)  
LRT: Chisq = .615, df = 2, p= 0.74

**model\_comb:**

MFonMB estimate (incongruent trials) = .009 (z = .782, p = .434)  
Crits estimate = 1.76 (z = 18.6, p < .0001)  
MFonMB:Crits estimate (congruent trials) =0.049 (z = 2.62, p < .01).  
LRT: Chisq = 10.65, df = 4, p < .05  
Bootstrapping: ???

**model\_all:**

Converged  
MFonMB estimate = 0.053 (z = 3.97, p < .0001)  
MB estimate = 0.313 (z = 8.87, p < .0001)  
MF estimate = .051 (z = 2.04, p < .05)  
LRT: Chisq = 27.3, df= 4, p < .0001  
Bootstrapping: ???

**t-test (congruent):**

Means & difference: 0.82846475 0.01159931 0.76237993 0.01421754  
t-test: t = -4.8426, df = 302, p-value = 2.05e-06

**t-test (incongruent):**

Means & difference: 0.49657019 0.01730872 0.47247182 0.01910213  
t-test: t = -0.9361, df = 282, p-value = 0.35

***With A0***

t-test: 173 subjects, 4755 congruent observations  
model: dropped 8

**model:**

MFonMB estimate = 0.143 (z = 9.62, p < .0001)  
LRT: Chisq = 238.1, df = 2, p < 2.2e-16  
Bootstrapping: ???

**model\_all:**

MFonMB estimate =0.146 (z = 9.56, p < .0001)  
MB estimate = .149 (z = 5.44, p < .0001)  
MF estimate = .045 (z = 1.65, p = .10)  
LRT: Chisq = 249.1, df = 4, p < 2.2e-16  
Bootstrapping: ???

**t-test:**

Means: 0.84918540 0.01316517 0.68780502 0.01553888  
t-test: t = -9.1679, df = 172, p-value < 2.2e-16

***dawstage2 (v2)***

270 subjects  
t-test: 244 subjects, 6232 observations  
models: 228 subjects, 5820 observations

**t-test:**

Mean choice when MFonMB > 0: 0.78613610, SE = 0.01222833  
Mean choice when MFonMB < 0: 0.74777764, SE = 0.01223421  
t-test: t = -3.3398, df = 243, p-value = 0.0009702

**model:**

MFonMB = .032 (z = 3.86, p = .0001)  
LRT: Chisq = 18.1, df = 2, p = .0001  
Bootstrapping: ???

***numberSum (v2)***

262 subjects  
t-test: 253 subjects, 6269 observations  
models: 247 subjects, 6118 observations

**t-test:**

Mean choice when MFonMB > 0: 0.79686255, SE = 0.01157544  
Mean choice when MFonMB < 0: 0.69343436, SE = 0.01231960  
t-test: t = -7.2774, df = 252, p-value = 4.313e-12

**model:**

MFonMB = .081 (z = 7.42, p = 1.18e-13)  
LRT: Chisq = 137.08, df = 2, p < 2.2e-16  
Bootstrapping: ???

***numberSum (v2): novel crits***

262 subjects  
t-test: 245 subjects, 1634 observations (had to drop some NaNs)  
models: 252 subjects, 1679 observations

**t-test:**

Mean choice when MFonMB > 0: 0.756, SE = .019  
Mean choice when MFonMB < 0: 0.672, SE = .019  
t-test: t = -3.267, df = 244, p-value = .00124

**model:**

MFonMB = .053 (z = 3.08, p = .0021)  
LRT: Chisq = 16.3, df = 2, p = .0003  
Bootstrapping: ???

***goalManip (v1)***

307 subjects  
t-test: 289, 7423  
model: 280, 7191

Same

**Simulations**

* 200 agents, 50 practice rounds, 175 real rounds. 26 critical trials (in 2-trial-type versions, half are incongruent).
  + Agents have 5 free parameters: learning rate, temperature, eligibility trace, model-based weight, and model-free weight. Goal weight = 1 – (model-based weight) – (model-free weight).
  + lr ~ U(0,1); temp ~ U(0,1.5); elig ~ U(.5,1); all weights ~ U(0,1) and then normalized. (For “No MF-goal” versions, goal weight = 0.)
  + Agents implement ??? for model-based learning and SARSA for model-free learning. Simple version of SARSA for MF-goal.
* Rewards/transitions are randomly generated the same way as in the behavioral experiments

***2-trial-type – no MF-goal***

**model (congruent):**

Converged  
MFonMB -0.008489 0.010234 -0.829 0.407  
LRT: 0.7509 2 0.687

**model (incongruent):**

Converged  
MFonMB 0.01449 0.01425 1.017 0.309  
LRT: 1.0351 2 0.596

**model\_comb:**

Converged  
MFonMB:Crits -0.02314 0.01866 -1.240 0.215   
LRT: 4.4603 4 0.3473

**model\_all:**

Converged  
MFonMB -0.008659 0.011530 -0.751 0.453  
LRT: 1.6642 4 0.7972

**t-test (congruent):**

Means & difference: 0.55354437 0.01437328 0.57831041 0.01381512  
t-test: t = 1.2995, df = 199, p-value = 0.1953

**t-test (incongruent):**

Means & difference: 0.48516865 0.02210400 0.46371528 0.02296334  
t-test: t = -0.6975, df = 191, p-value = 0.4864

***2-trial-type – with MF-goal***

**model (congruent):**

Converged  
MFonMB 0.06354 0.01162 5.468 4.55e-08 \*\*\*  
LRT: 40.944 2 1.286e-09

**model (incongruent):**

Converged  
MFonMB -0.003317 0.014290 -0.232 0.816  
LRT: 0.0539 2 0.9734

**model\_comb:**

Converged  
MFonMB:Crits 0.074475 0.018954 3.929 8.52e-05 \*\*\*  
LRT: 26.688 4 2.299e-05

**model\_all:**

Converged  
MFonMB 0.0790991 0.0007366 107.4 <2e-16 \*\*\*  
LRT: 51.607 4 1.667e-10

**t-test (congruent):**

Means & difference: 0.65398341 0.01691908 0.55460675 0.01330697  
t-test: t = -4.677, df = 199, p-value = 5.367e-06

**t-test (incongruent):**

Means & difference: 0.49320437 0.02381953 0.48333333 0.02054743  
t-test: t = -0.3239, df = 191, p-value = 0.7464