Intro

* Brief overview of task switching
* Describe VTS in contrast to cued
* Describe the significance of switch rate, previous studies that have used it as a DV of interest
* Bring in some studies that have found changes in behavior over time on other tasks to be meaningful
* Describe our paradigm and briefly state that we will also be testing for similar effects in openly available data from two other similar paradigms run by other labs

Experiment I Method

* Describe our standard VTS number stroop paradigm
* Briefly describe interval manipulation but state that it is not relevant to the current analyses and that analyses involving those manipulations can be found in our other manuscript (link bioRxiv)
* Changes in switch rate over time will be tested using a multilevel logistic Bayesian regression where probability of switching is the DV and cumulative trial number is the IV. Trial number will be included as both a group- and individual-level coefficient.
* Changes in switch cost over time will be assessed using a multilevel Bayesian regression where log-transformed RT is the DV and cumulative trial number and switch/repeat are IVs, along with their interaction term.
  + If switch cost changes over time, we’ll see an interaction between switch/repeat and cumulative trial number, indicating that the difference between switch Rt and repeat RT changes with cumulative trial number.
  + All IVs will be included in the models as group- and subject-level coefficients.
  + If there is no interaction, the interaction terms will be removed and the main effect of trial number on RT will be assessed. This will allow us to test for changes in RT over time while including the effect of switching on RT as a covariate.
* Individual-level coefficients will be used to test for correlations between changes over time if any are present.

Experiment I Results

* Switch rate significantly decreases over time (effect of trial number on switch probability is significant).
* Switch cost does not change over time (no interaction between trial number and switch/repeat in predicting RT)
* RT declines over time when the effect of switching on RT is included as a covariate.
* The RT and SR declines are weakly (r=.2) related on an individual level.

Experiment I Discussion

* Experiment 1 identified the presence of a significant change in SR over the course of a task that might provide more (or different) insight than an examination of mean SR.
* Difficult to tell from this experiment alone what processes might be underlying the change – could be fatigue, changes in strategy, practice, or a combination.
  + Combination of increased speed and more repeats suggests a possibly increased reliance on bottom-up processing, possibly due to fatigue, practice, or both.
* Emphasize need for replicating the finding in another sample and another task (could be due to directions or stimulus conflict from the number stroop, for example)

Experiment 2A Intro

* Introduce Experiment 1 from Frober’s paper – participants underwent a ‘training’ portion where there was no reward, it was just a normal double registrant VTS task. Then, they underwent a ‘test’ portion where participants were given performance-contingent rewards on that same task.
* With this experiment, we plan to assess 1) whether the decline in SR replicates in a smaller sample with a slightly altered task, 2) whether it is influenced by the introduction of reward and 3) whether the relationship between RT declines and SR declines replicates.

Experiment 2A Method

* Briefly describe the task used (basic double registrant) and the reward conditions (no reward during the ‘training’ phase, performance contingent during the ‘test’ phase). In both phases, participants were instructed to choose randomly with the standard Arrington instructions. I imagine this can be very brief because we can direct readers to the paper for a more detailed explanation.
* Data was preprocessed following the same criteria as in the original paper.
* Bayesian logistic regressions are used to test for the presence of a switch rate decline and the effect of the reward manipulation.
  + If a switch rate decline exists, we expect a main effect of successive trials on the probability of switching.
  + If increased motivation reduces the decline, we expect an interaction between the experiment phase (presence of reward) and the decline in SR.
* To assess the presence of RT decline and reaffirm the lack of a decline in switch cost, we’ll first test for a decline in switch cost by testing for an interaction in switch/repeat and successive trial number on log RT.
  + This is necessary to make sure that RT decline is not significantly affected by switching, which would confound it with declines in switch rate.
  + However, it also serves to reaffirm the original finding that switch costs seem to be stable throughout the experiment.
  + Reward presence will be included in the models as a covariate to account for additional variance. Because it is possible that the increased motivation from the reward might also influence declines in RT/switch cost, interactions between those variables will be tested as well.
* Assuming decline in RT is not confounded with switching, we’ll assess the relationships between decline in SR and decline in RT by using subject level ‘trial number’ coefficients from the model with switch probability as a DV and the model with log RT as a DV. In both models, covariates that might affect the DV (reward presence for the switch rate model, reward presence and switch/repeat for the RT model) will be included to control for their effects.
  + We’ll test for relationships between these coefficients using a correlation.

Experiment 2A Results

* Bayesian logistic regression assessing switch rate revealed no interaction between reward presence and trial number, indicating no effect of performance-contingent reward on switch rate declines. The interaction term was then removed from the model to assess the main effect of trial number.
* The main effect of trial number was significant, indicating a significant decline in switch rate across both phases of the experiment.
* There was no three-way interaction between reward/switching/trial number on RT. After removing the three way interaction, none of the two way interactions were significant either. This suggests that any changes over time in RT exist independent of reward and switching effects on RT.
* When interaction terms were removed, there was a significant decline in RT over time (main effect of trial number coefficient was significant).
* Subject-level ‘trial number’ coefficients from the switch rate and RT models containing no interaction terms (but all covariates) were not significantly correlated with each other (p ~= .50), and the relationship was in the opposite direction of our original result.

Experiment 2A Discussion

* Even in a sample as small as ~30 subjects, there is a visible decline in SR over the course of a task. This suggests that the decline is replicable and worth exploring further.
* The presence of reward does not seem to reduce the decline, possibly indicating that the decline is not related to general declines in motivation. Alternatively, the presence of reward might not have boosted motivation, although the reward is performance-contingent so this seems somewhat unlikely.
* While the lack of decline in switch cost replicated, the relationship between RT declines and SR declines did not replicate. While this does not rule out increases in bottom-up bias as a possible mechanism (solely repeating more might suggest an increase in bottom-up bias alone), it does suggest that the relationship between RT decline and SR decline will likely not yield insight into the mechanisms underlying SR decline.

Experiment 2B Intro

* While the presence of reward did not reduce SR decline, previous work has found that reducing the number of voluntary trials (and thus choices) can increase switch rate. It’s possible that this effect is additionally visible in a reduction/elimination of SR declines over time when fewer voluntary trials are present.
* Frober’s Experiment 3 provides a good opportunity to test this – the design is exactly the same as in experiment 1, except only 20% of trials are voluntary throughout both the non-rewarded baseline and rewarded test phases.

Experiment 2B Methods

* Describing the task here might only be like a sentence or two because it’s exactly the same as 2A except for the 80% forced choice trials (and I can and will reference the original paper). Again, the same preprocessing stream as described in the original paper was used here. One difference of note is that participants in this experiment were not given the Arrington instructions. Only voluntary choice trials are examined (as we are interested in task choices).
* The same analysis method as in 2A is used here, a Bayesian logistic regression with switch probability as a DV and an interaction between reward presence and trial number as IVs. If there is no interaction, the interaction term will be removed and main effects will be tested.
* The effect of trial number on switch probability in this experiment will be compared to the effect of trial number on switch probability in experiment 2A.
  + Because the differences in sample size across the two experiments might be a confound (much fewer voluntary trials to analyze in this one), we have less power to detect the decline in 2B than in 2A. Therefore, we will not rely solely on the significance of the effect of trial number on switch probability in this experiment to compare the two.
  + Instead, we will compare the CIs of the effect of trial number on switch probability across studies. While we expect that the CI of the effect will be larger in 2B because of the reduced power, we can more safely conclude that the effects in 2A and 2B are different if the CIs do not overlap.

Experiment 2B Results

* There was no interaction between reward presence and trial number on the probability of switching. However, there was also no effect of trial number on switching when the interaction term was removed, suggesting no detectable decline in SR in this version of the task.
* The CIs of the effect of trial number on switch probability in Experiment 2A and 2B did not overlap, suggesting that the lack of decline is not just due to a reduction in the power to detect the effect.

Experiment 2B Discussion

* The lack of SR decline in 2B suggests that reducing the number of times that a participant can choose tasks might reduce or eliminate the decline. Recent work that suggests limiting choices increases overall switch rates might be better characterized by reducing or eliminating switch rate decline rather than an effect acting on average switch rates uniformly throughout the task.
* If fewer choices reduces the decline, the decline in SR might specifically be linked to a type of ‘choice fatigue’ that occurs not due to overall fatigue or overall practice, but to the demands of choosing a task repeatedly.
* An alternative explanation might be that participants in this version were not given the Arrington random instructions, but were instead told to choose tasks freely. This explanation might posit that the decline in SR is linked to decays in the representation of ‘random’ over time. Because this representation was not present in the 2B task, but was in the other previous tasks, this explanation might account for differences.

Experiment 3 Introduction

* To examine whether the elimination of SR decline in 2B is due to lack of Arrington instructions or fewer choices, we will examine the Braem experiment.
* The Braem experiment included only 50% voluntary trials, but on those trials participants were instructed to perform randomly. If the lack of decline is due to fewer choices and not the lack of a randomness representation, we expect no decline here as well.
* The Braem experiment also allows us to test whether conditioning participants to switch or repeat tasks might affect declines in SR – the original paper finds that it changes mean SR, so we might expect an effect on SR decline as well.
* While we have focused mainly on group-level declines, it is possible that individual differences in SR decline might provide valuable information (even if there is no detectable group-level decline). As such, we plan to examine relationships between individual SR declines and BIS/BAS ratings.
  + Because there is no relationship between mean SR and BIS/BAS, a relationship between SR decline and BIS/BAS would suggest that the declines provide more information than the more commonly used mean SRs.
  + Any relationships would also further elucidate any possible mechanism behind the decline.

Experiment 3 methods

* Briefly describe Braem’s method. Direct readers to paper. Highlight mainly that it is also double registrant, describe the reward manipulation and emphasize that again we are only analyzing the voluntary trials in the experiment.
* For this experiment, preprocessed data was publicly available and was used in analyses to ensure our preprocessing stream was consistent with the original author’s.
* As in the other experiments, decline in SR will be assessed using a Bayesian logistic regression with trial number as the IV. To assess the effect of different reward conditions, reward condition is included as an IV along with an interaction term between the two.
* If there is no significant interaction, the interaction term will be removed and the main effects will be assessed.
* From the final logistic model, we will test for relationships between individual-level ‘trial number’ coefficients and BIS/BAS subscores.

Experiment 3 results

* There was no interaction between reward condition and trial number in predicting switch probability, suggesting that conditioning people for repeats/switches does not influence SR change over time.
* However, when the interaction term was removed, there was also no effect of trial number on switch probability. This supports the idea that providing participants with fewer choices might eliminate declines in SR over time.
* There was a moderate negative correlation (r= -.49) between SR decline and BIS score collapsed across reward conditions.
* There was a weak-to-moderate positive correlation (rho = .37) between SR decline and BAS fun-seeking score collapsed across reward conditions.
  + Rho, a nonparametric correlation measure, was used here because BASf was not normally distributed (tested using a Shapiro-Wilk test).
* No relationships were found between BASr and BASd and SR decline.
* No relationships were found between mean switch rates and BIS/BAS scores when collapsed across reward conditions.

General Discussion

* Brief summary – switch cost RT doesn’t change over time, while SR seems to decrease in a fully voluntary paradigm. Limiting trials on which choices are made seems to eliminate the decline on a group level. Even still, individual differences in SR change seem to be informative beyond the more commonly used average SR measures.
* Review the idea that SR decline might be related to a transition to increased bottom-up and/or reduced top-down processing, citing work that links repeats to bottom-up bias. Note that the original relationship found between SR decline and RT decline should not be considered reliable as it didn’t replicate in the Frober dataset, but that increases in bottom-up processing are still a viable explanation for the decline.
* Discuss the idea that reducing choice trials eliminates the decline, contextualizing this using other work that analyzed mean SR reductions from this type of manipulation. Suggest that conceptualizing the effects of this manipulation as a reduction in decline rather than an overall reduction might be more accurate, or at least provide a different persective for the effect.
* The elimination of SR decline with fewer choices might suggest that the decline occurs not from a result of repeated task performances, but repeated task choices. Dig up some work that looked at the effects of repeated decisions and compare those findings to this.
* Discuss BIS/BAS findings – first make the point that changes in SR over time seem to provide different, and not necessarily better, information. Make this point by discussing how Braem’s reward manipulation was visible in average SR, but not changes, while individual differences in BIS/BAS scores were related to SR changes and not overall SR.
* Discuss possible implications of individual differences findings, focusing mainly on BIS-SR change relationship as it’s pretty strong. Higher BIS scores meant greater declines in SR. High scores on BIS indicate that a person avoids aversive events. It’s possible that the increased difficulty of a switch trial causes switches to be considered aversive, which would account for the relationship. The conception of switches as aversive might provide an alternative explanation for declines over time in full VTS paradigms – it’s a drift towards the natural tendency to avoid aversive switching. This tendency is initially inhibited in order to choose tasks randomly. This doesn’t rule out a shift towards bottom-up and away from top-down processing, as both can work in tandem.
* High BAS fun seeking scores meant increases in switch rate over time. IT’s possible that the increased difficulty of switch trials causes them to be seen as a challenge, which is more attractive to those higher in fun-seeking during an otherwise banal task. This relationship is weaker than the BIS-SR change relationship and should be interpreted with more caution, but the idea that switches can serve to alleviate boredom or provide stimulation to those more inclined to seek it should be explored further.
* Limitations – individual difference analyses in the BIS/BAS scores are possibly underpowered and attempts should be made to replicate them. While the analyses make a strong case for considering changes in SR as an important performance metric, it’s still unclear what cognitive mechanism or traits might underlie the changes over time. Future work might aim to explore the possibilities by examining relationships between Sr changes and brain activity or manipulating of top-down and bottom-up bias.