Contributions of Fatigue and Automatic Processing to Cognitive Flexibility

Michael J. Imburgio[1], Joseph M. Orr[1,2]

[1]Department of Psychological & Brain Sciences, Texas A&M University
[2]Texas A&M Institute of Neuroscience

TEXAS A&M UNIVERSITY

CONGAlab

Introduction

• Cognitive flexibility is the ability to adapt to different situations and switch between tasks and task sets. In experimental settings, it is operationalized as task switching.

• More recently, the drift diffusion model has been applied to these tasks to quantify latent decision-making variables.

• The model is most commonly used in task switching to quantify processes related to switch cost, however it more generally measures basic decision making processes.

• Little work has examined how task switching performance might change over time, or (by extension) how task length might affect commonly used performance measures.

• The current study examines how basic task switching performance measures, such as switch cost and switch rate, change throughout the task. We also used a drift diffusion model to examine how decision making processes might change over time.

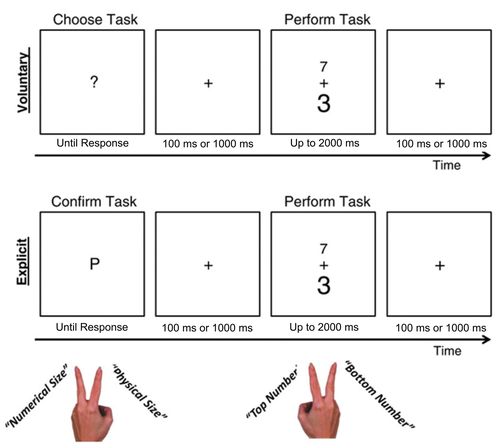
Methods

• Participants performed a number Stroop task. Each trial required participants to determine which of two numbers was numerically or physically larger.

• In the explicit condition, each trial began with either an 'N' (indicating a numerical comparison trial) or a 'P' (indicating a physical comparison trial).

• In the voluntary condition, each trial began with a '?' indicating the subject should choose which task to perform. Participants were instructed to choose randomly between tasks without using a pattern.

• Participants performed 390 trials of either the explicit (n = 116) or voluntary (n = 100) task.



• Voluntary task switching refers to situations in which a participant can choose whether to switch to a different task or repeat the same task.

• Explicit task switching refers to situations in the task dictates when a participant should switch between tasks, such as when a cue dictates the task.

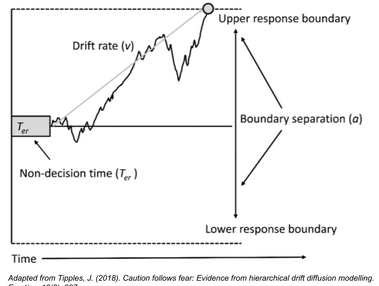
Methods

• To examine which cognitive processes might change over time, hierarchical drift diffusion models were fit for each version using the HDDM python package.

• To estimate trial-by-trial parameter changes, the HDDMRegressor function was used to fit a number of candidate regression models.

• For both task versions, best-fitting models that included switch effects on parameters and linear changes in drift rate and response boundary with increasing trial number.

Drift Diffusion Model



Adapted from Tipples, J. (2018). Caution follows fear: Evidence from hierarchical drift diffusion modelling. Emotion, 18(2), 237.

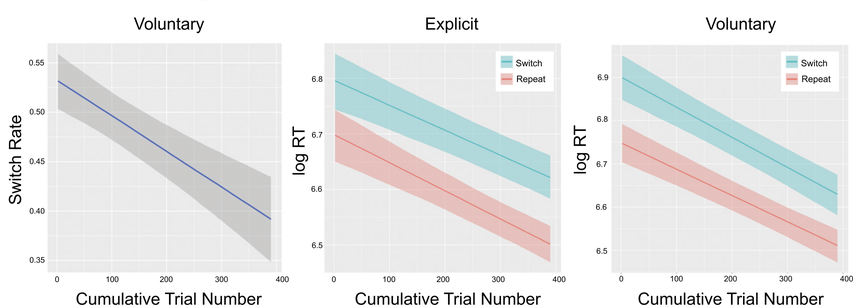
• Relationships between cumulative trial number and RT, switch cost, and switch rate were examined with Bayesian hierarchical models using the *brms* R package.

• To further examine individual differences in flexibility, relationships between subject-level coefficients from the hiearchical regressions and hierarchical drift diffusion models were examined.

• Because the drift diffusion model is derived from RT and accuracy distributions, we did not examine correlations between RT measures and model parameters.

Results

Changes in Switch Rate and RT Over Time



• In the voluntary version, participants' switch rates gradually decreased over time.

• While there was no effect of trial number on switch cost RT, RTs for both repeat and switch trials declined over time within both task versions.

• Faster overall responses and an increased tendency to repeat tasks might indicate a shift towards greater bottom-up processing/automaticity.

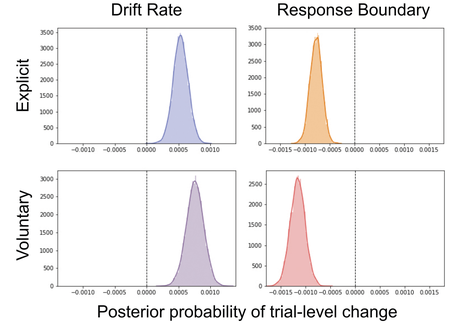
Results

Changes in Model Parameters Over Time

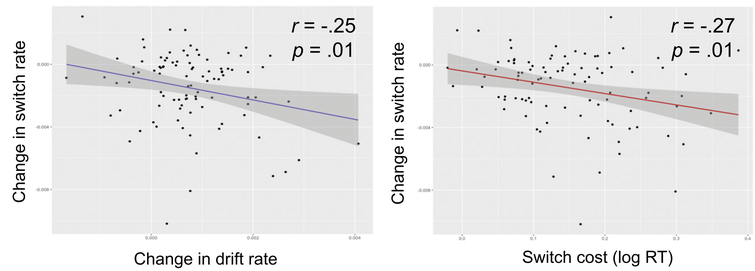
• Drift rates increased over time, indicating more efficient evidence accumulation.

• Response boundaries decreased over time, indicating less information was required to reach a decision.

• Neither effect depended upon whether the trial was a switch or a repeat.



Individual Difference Analyses



• Changes in drift rate were related to changes in switch rate.

• Greater improvement in drift rate over time was associated with greater decline in switch rate as the task progressed.

• Overall switch cost was related to decline in switch rate.

• Participants with larger switch costs displayed steeper declines in switch rate as the task progressed.

Conclusions

• Faster responses and an increased tendency to repeat tasks over time might indicate an increased reliance on automatic/bottom-up processing.

• Decreases in the response boundary over time might quantify this increased reliance on bottom-up processing, while increases in drift rate might capture practice effects.

• The relationships between change in drift rate and change in switch rate, as well as switch cost and change in switch rate, might provide insight into individual differences in flexibility.

• Task length should be considered when switch rate is used as a measure of flexibility.