Learning to stop or waiting to go: Targets of adaptive (Bayesian?) updating during inhibitory control

Timothy Verstynen (timothyv@cmu.edu)[1], Kyle Dunovan[2], Brian Kranier[1], Leo Scholl[1], Tara Molesworth[1]

1. Dept. of Psychology & Center for the Neural Basis of Cognition
Carnegie Mellon University

2. Dept. of Psychology & Center for the Neural Basis of Cognition
University of Pittsburgh

Reprints can be downloaded here: www.psy.cmu.edu/~coaxlab/posters/Verstynen_SFN14.pdf

Background

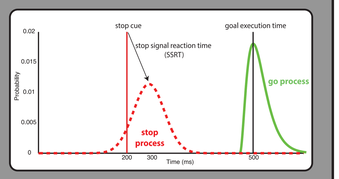
Action selection can be viewed as a race between internal processes that facilitate execution of a desired response (Go process) and processes that suppress alternative responses (Stop process).

Computational models have shown that, on very fast time-scales (i.e., milliseconds) both the go and stop processes are updated probabilistically (Shenoy & Yu, 2011).

It remains unclear whether trial-by-trial learning modulates the go process, the stop process or both.

Question

When the expected timing of a stop signal are learned probabilistically, do participants modulate their decision to go or the efficiency of stopping?



Methods

Participants

Neurologically healthy adults (N=75; mean age = 22) were recruited from the local student population at Carnegie Mellon University. All testing was approved by the local Institutional Review Board.

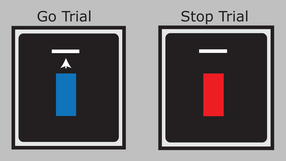
Stop Signal Task

Participants saw a bar "filling" towards a line (the target). The bar reached the line at 500 ms after trial onset. Participants were instructed to press the space key when the bar reached the target. The bar stopped moving when the key was pressed. Participants were rewarded based on how close they were able to stop the moving bar to the target (Go Trials n = 600)

Stopping Probe Trials (n = 80)

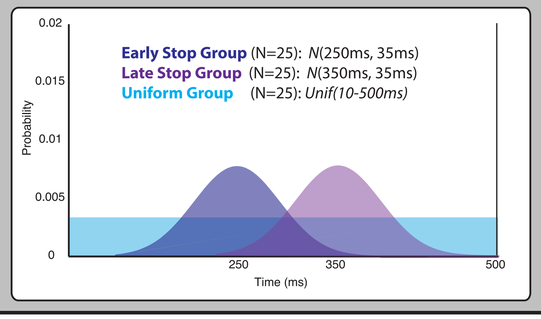
Stopping Cue: The bar stops & turns red before it hits the line.

Probe Times:
200 ms (n = 16)
250 ms (n = 16)
300 ms (n = 16)
350 ms (n = 16)
400 ms (n = 16)



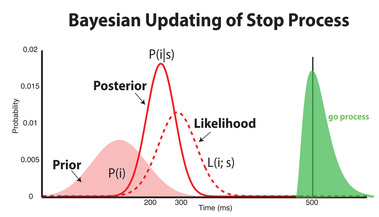
Stopping Context Trials (n=200)

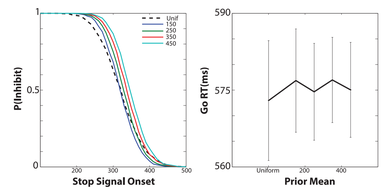
Context stop trials were randomly selected according to one of 3 probability distributions (1 distribution per subject)



MCMC Simulations

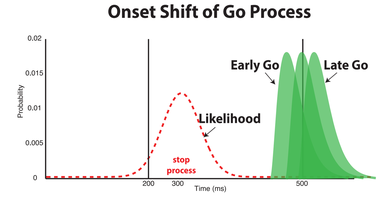
Bayesian Updating of Stop Process

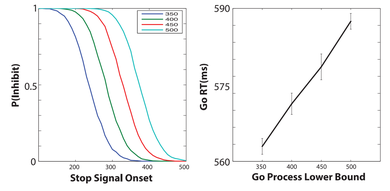




Better stopping, no change in Go Trial RT

Onset Shift of Go Process

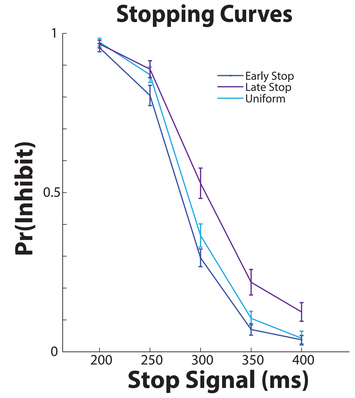




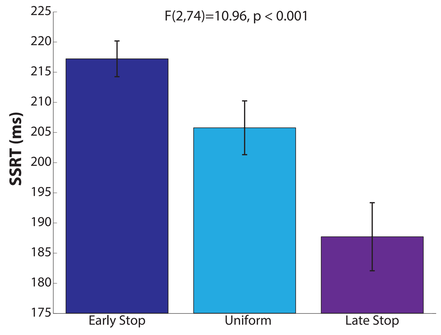
Shifted stopping curve, increased Go Trial RT

Behavioral Data

Stopping Curves



Stop Trials

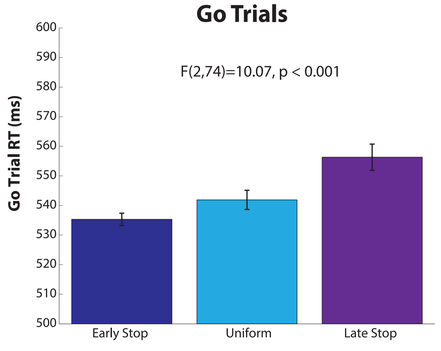


- Stopping curves were shifted to the left in the Early Stop group, relative to the Uniform group, leading to an increase in estimated SSRT.

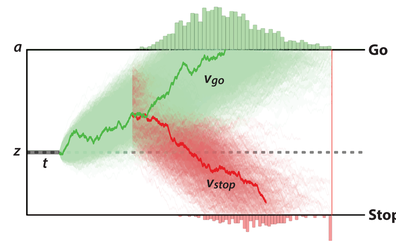
- The Late Stop group was more likely to stop than the Uniform group, leading to right-shifted stop curves and faster SSRTs.

- Reaction times (RT) on Go Trials increased in the Late Stop group and decreased in the Early Stop group, relative to the Uniform group.

Go Trials

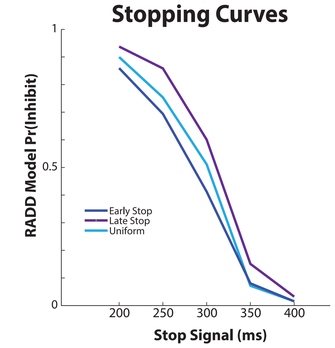


Race Against Drift Diffusion (RADD) Fits

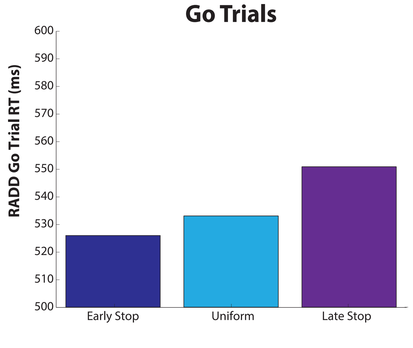


Mean group data were fit to a drift diffusion model (see Abstract # 14238, Poster KK12) that captures the performance of decisions in this modified stop signal paradigm.

Stopping Curves



Go Trials



Model Parameters

	Early	Uniform	Late
Stop Drift Rate (v_stop)	0.81	0.81	0.85
Go Drift Rate (v_go)	1.04	1.09	1.10
Boundary Height (a)	0.43	0.44	0.47
Starting Point (z)	0.20	0.19	0.20
Non-decision Time (t)	0.30	0.30	0.31

Preliminary analysis on the model fits suggests that the drift rate (v_{go}) and boundary height (a) of the Go process most consistently change across groups. Drift rate of the stop process (v_{stop}) only differs in the Late Stop group.

Summary

Exposure to a set of probabilistically determined stop signals leads to a systematic shift in inhibitory control during Stop trials and response speeds during Go trials.

Changes in stopping performance in the Early and Late Stop groups, relative to the Uniform group, were consistent with a modulation of the go process and not with a model of Bayesian updating on the stop process.

Fits to a drift diffusion process model preliminarily confirmed that different stopping probabilities shifted the rate and boundary criterion for the go process.

Conclusion

Trial-by-trial updating of expectations in the stop signal task occur by modulation of the go process and not by modulation of the ability to suppress a planned action.

References

Shenoy P, Yu AJ. Rational decision-making in inhibitory control. Front Hum Neurosci. 2011 May 27;5:48.