

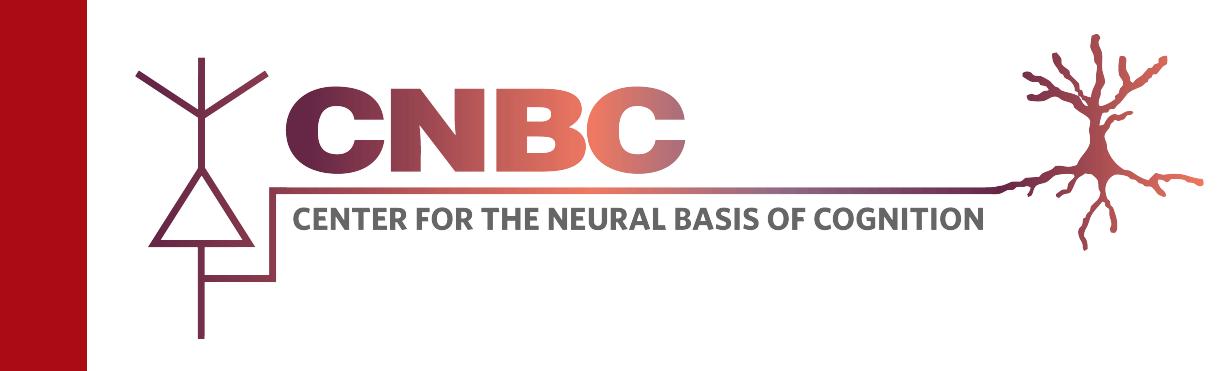


How Reward and Punishment Influence Proactive and Reactive Inhibition

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Background

- There are two ways to stop an action:

Reactive stopping: transient stimulus-driven cancellation of a planned action (Logan & Cowan, 1984).

Proactive stopping: sustained and anticipatory maintenance of goal-relevant information to prevent building or generating a response (Braver, 2012).

- These processes are thought to utilize different executive control circuits, which may also affect how they use reward information to update future responses (Haber & Knutson, 2010; Leotti & Wager, 2009).

Hypothesis

Proactive and reactive stopping are independent processes that incorporate reward signals in different ways.

Methods

Participants

Neurologically healthy adults (N=24; 10 male; mean age = 22 +/- 4.32) were recruited from the local student population in Pittsburgh. All testing was approved by the local Institutional Review Board.

Go Trials

Participants saw a bar "filling" towards a line (the target). The bar reaches 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 financially rewarded based on how close they were able to stop the moving bar to the target.

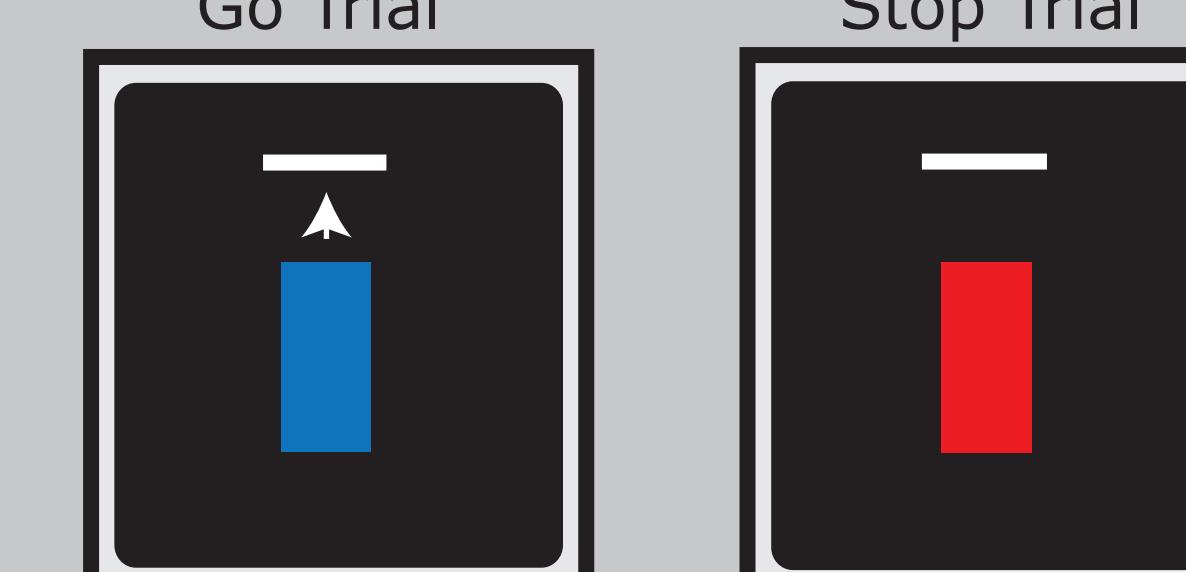
On some trials the bar would stop before it hit the line. This stopping was indicated in one of two ways.

Reactive Stopping (121 Go, 100 Stop)

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

Stopping Times:

- 200 ms (n = 20)
- 250 ms (n = 20)
- 300 ms (n = 20)
- 350 ms (n = 20)
- 400 ms (n = 20)

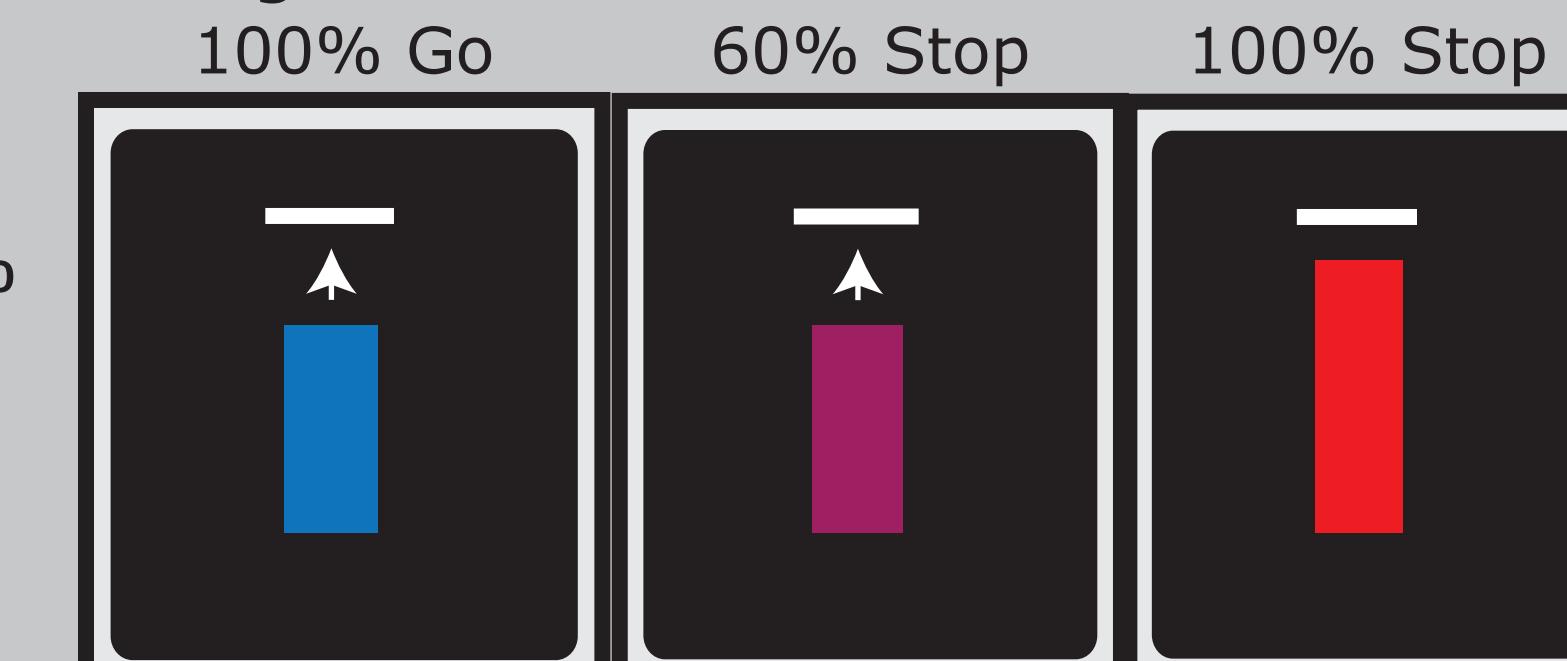


Proactive Stopping (120 Go, 120 Stop)

Stopping cue: Decide whether or not to stop or go based on the bar's color. Color represents the probability that the bar will stop 100ms before the target line.

Stopping Probability:

- Blue = 0%
- Dark Purple = 20%
- Purple = 40%
- Dark Pink = 60%
- Pink = 80%
- Red = 100%



Reward Manipulation

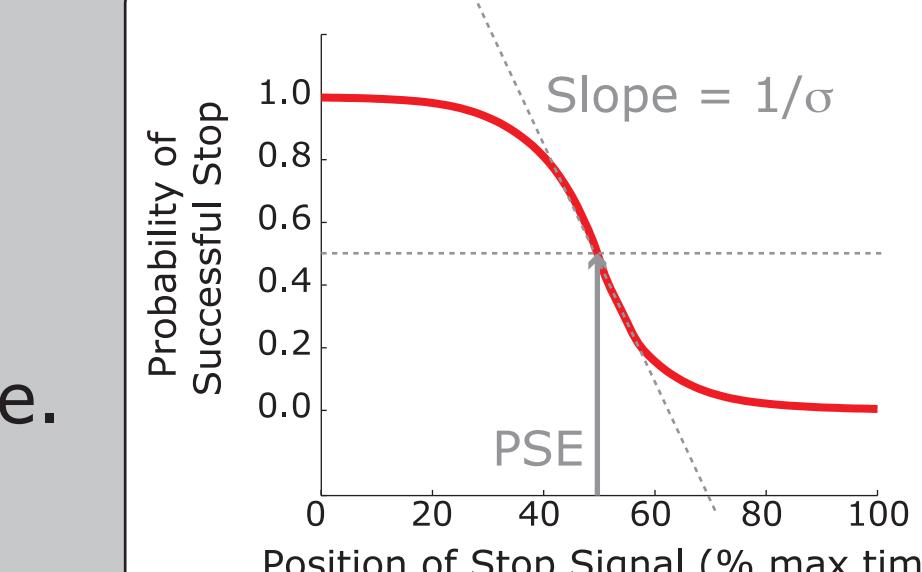
Baseline (BSL): Reward for correctly stopping and penalty for incorrectly going were equal.

High Reward (RWD): Increased reward for *correctly stopping* was higher than penalty for *incorrectly going*.

High Penalty (PNL): Increased penalty for *incorrectly going* was higher than reward for *correctly stopping*.

Data Analysis

Point of subjective equality (PSE): The point at which the stopping curve crosses the 50% probability boundary.

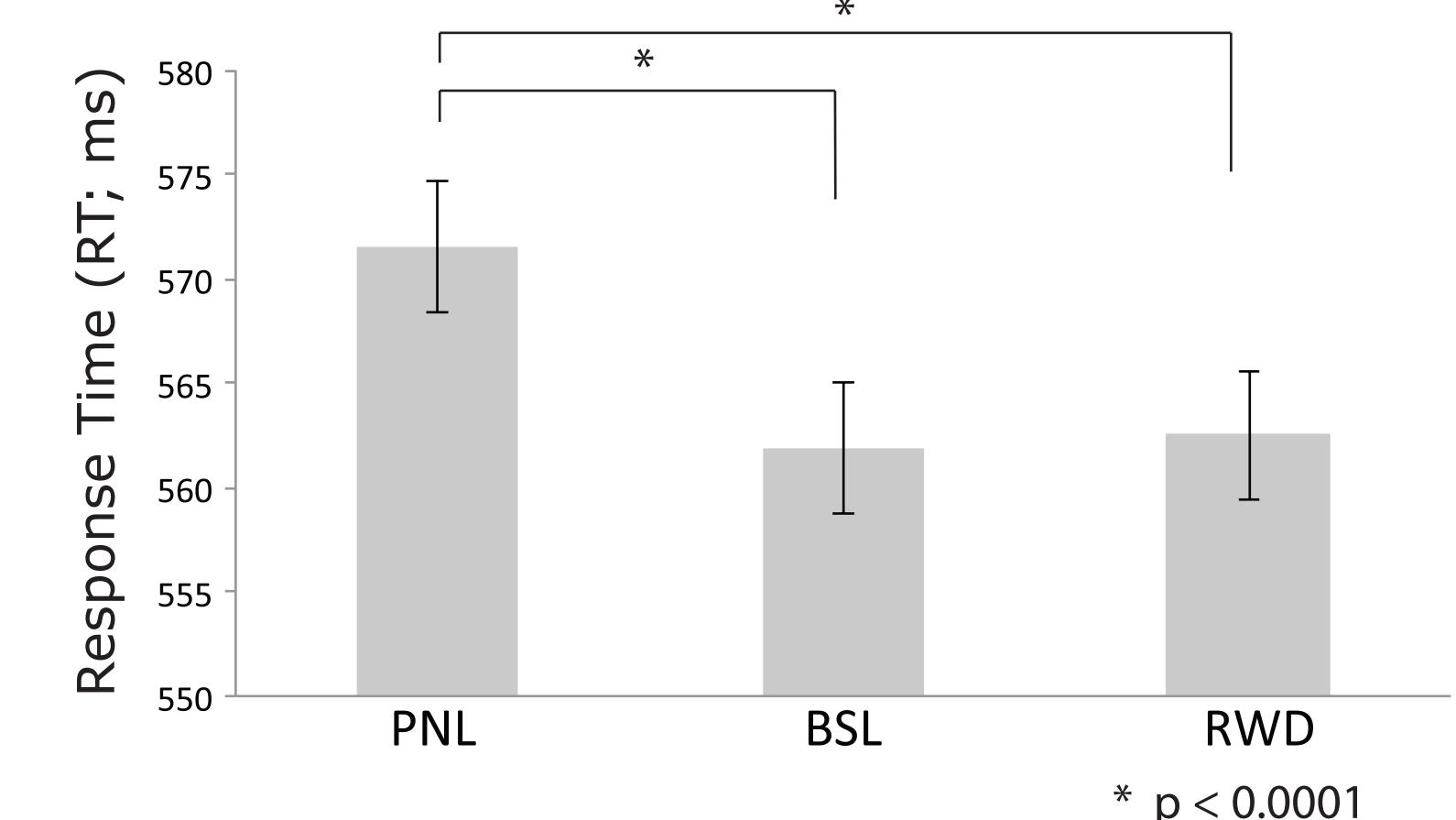
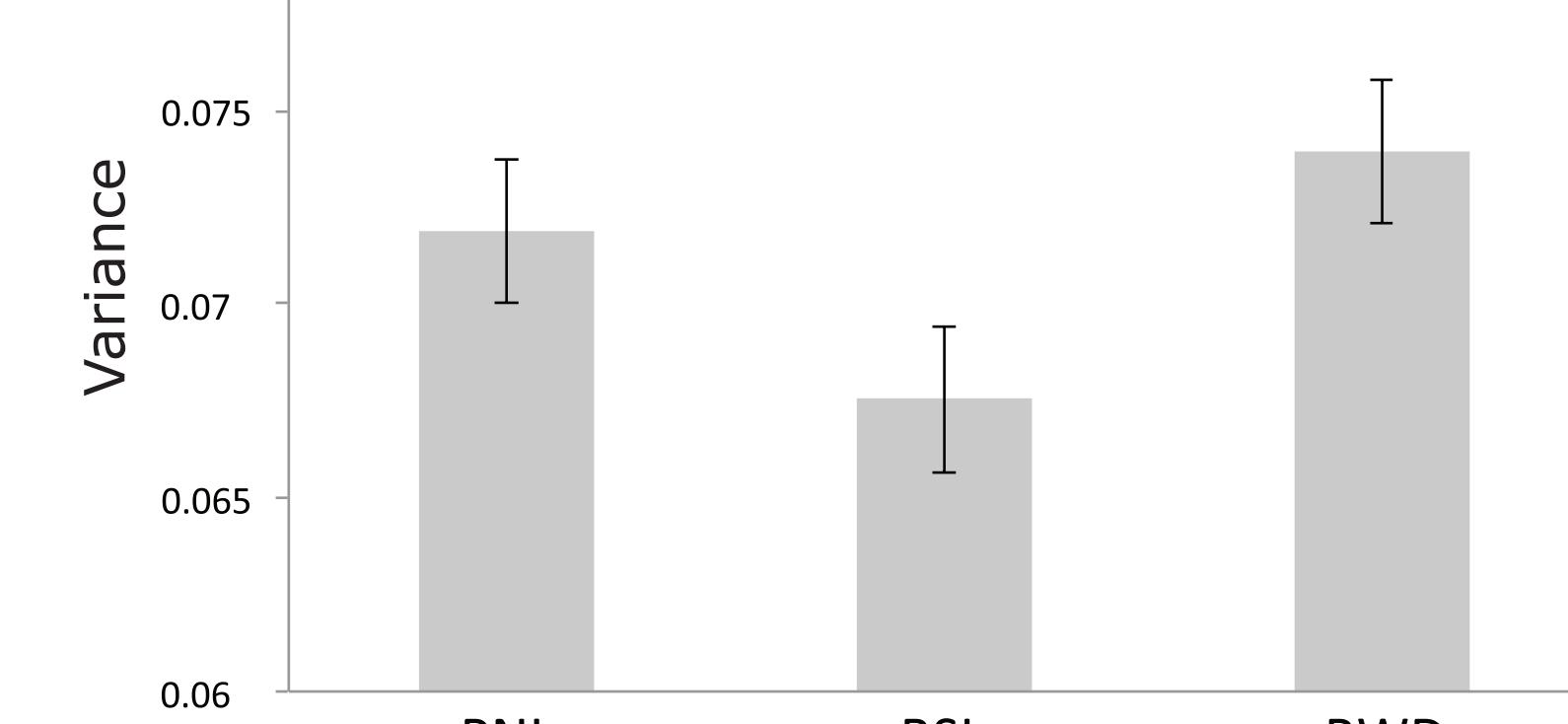
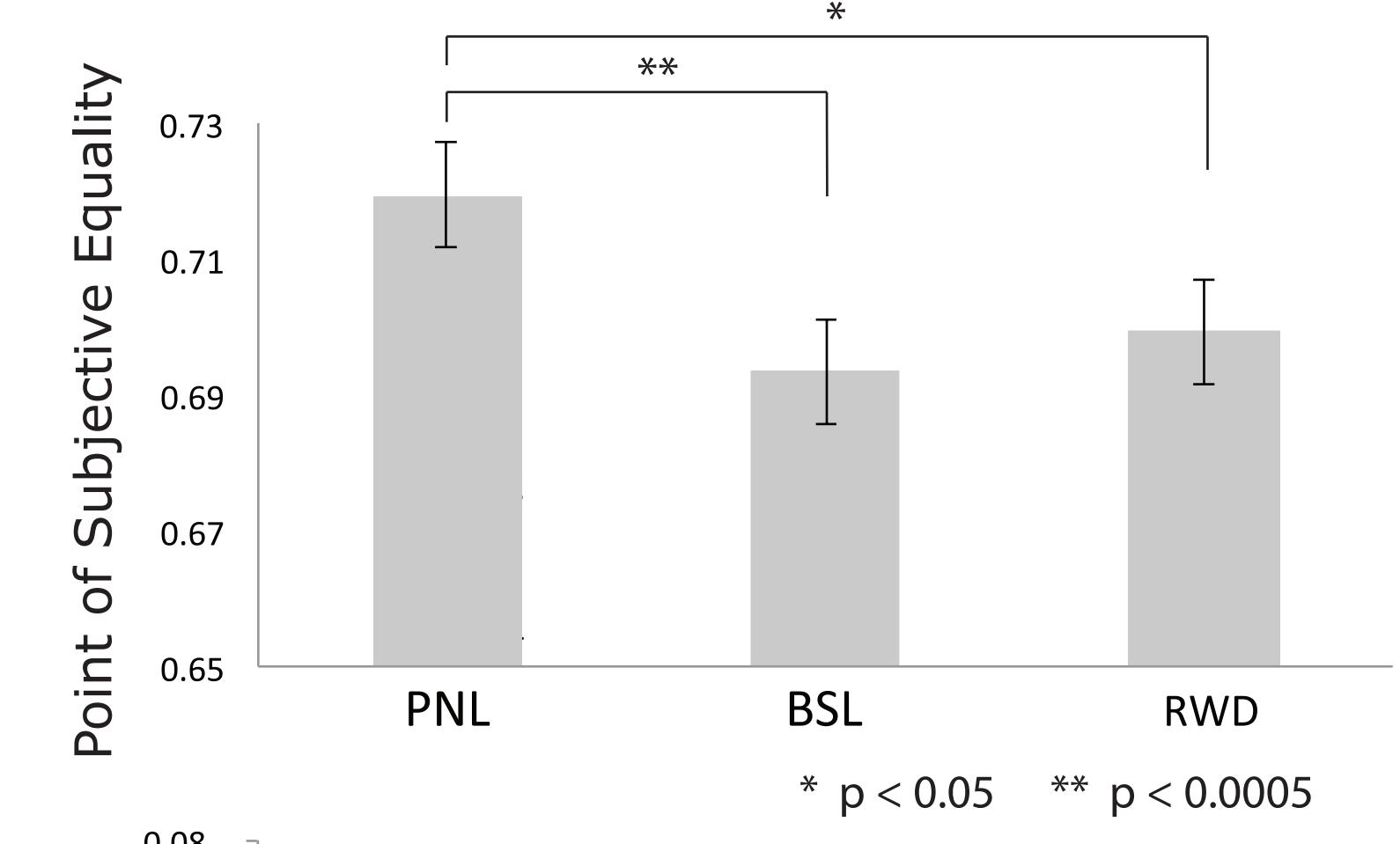


Variance: Inverse of the slope of the curve.

Reactive Stopping

Stopping Means

Increasing the penalty for incorrect responses (i.e., key presses during a stop trial) pushed the PSE later compared to the baseline and reward blocks ($F[2,46] = 7.46$, $p < 0.001$).



Stopping Variance

Manipulating the reward structure did not affect the precision of stopping responses ($F[2,46] < 1$).

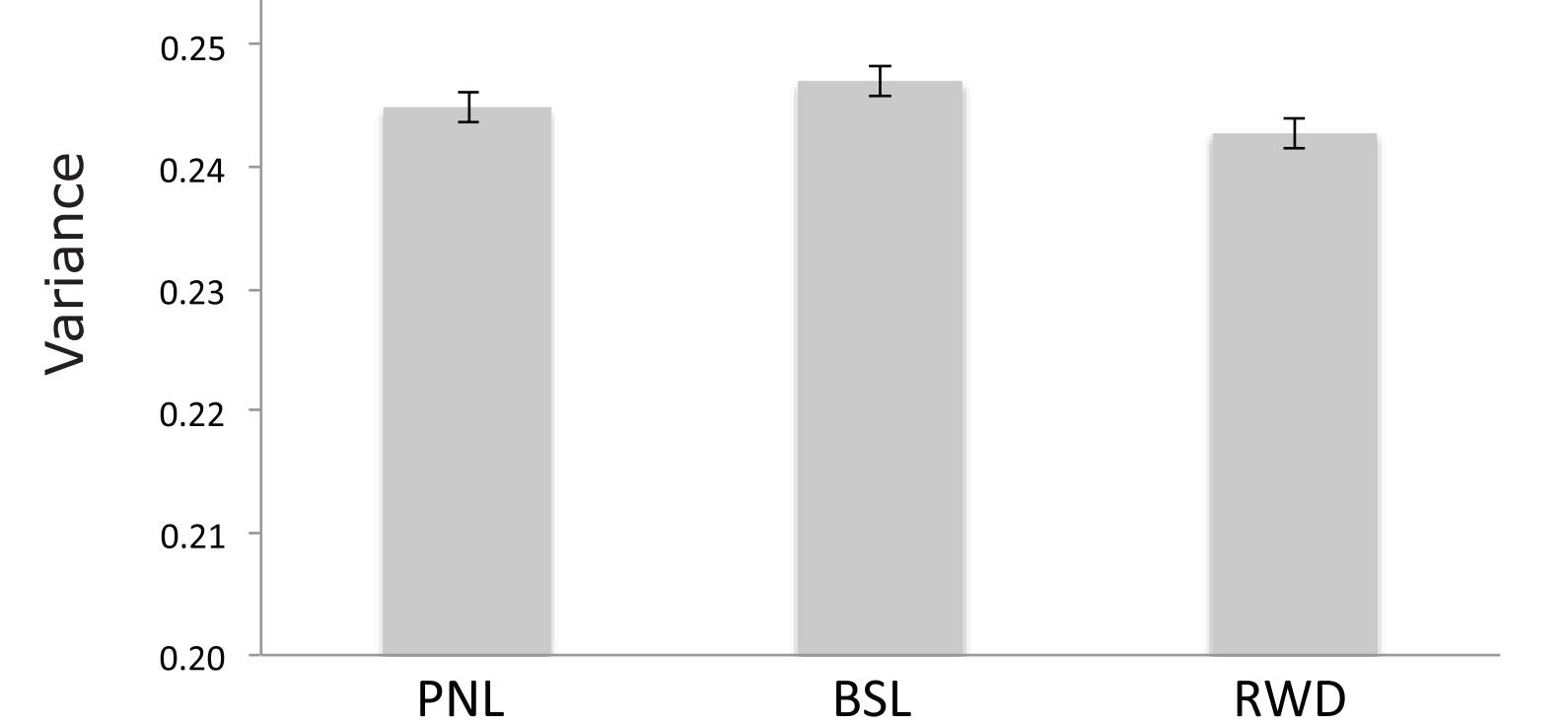
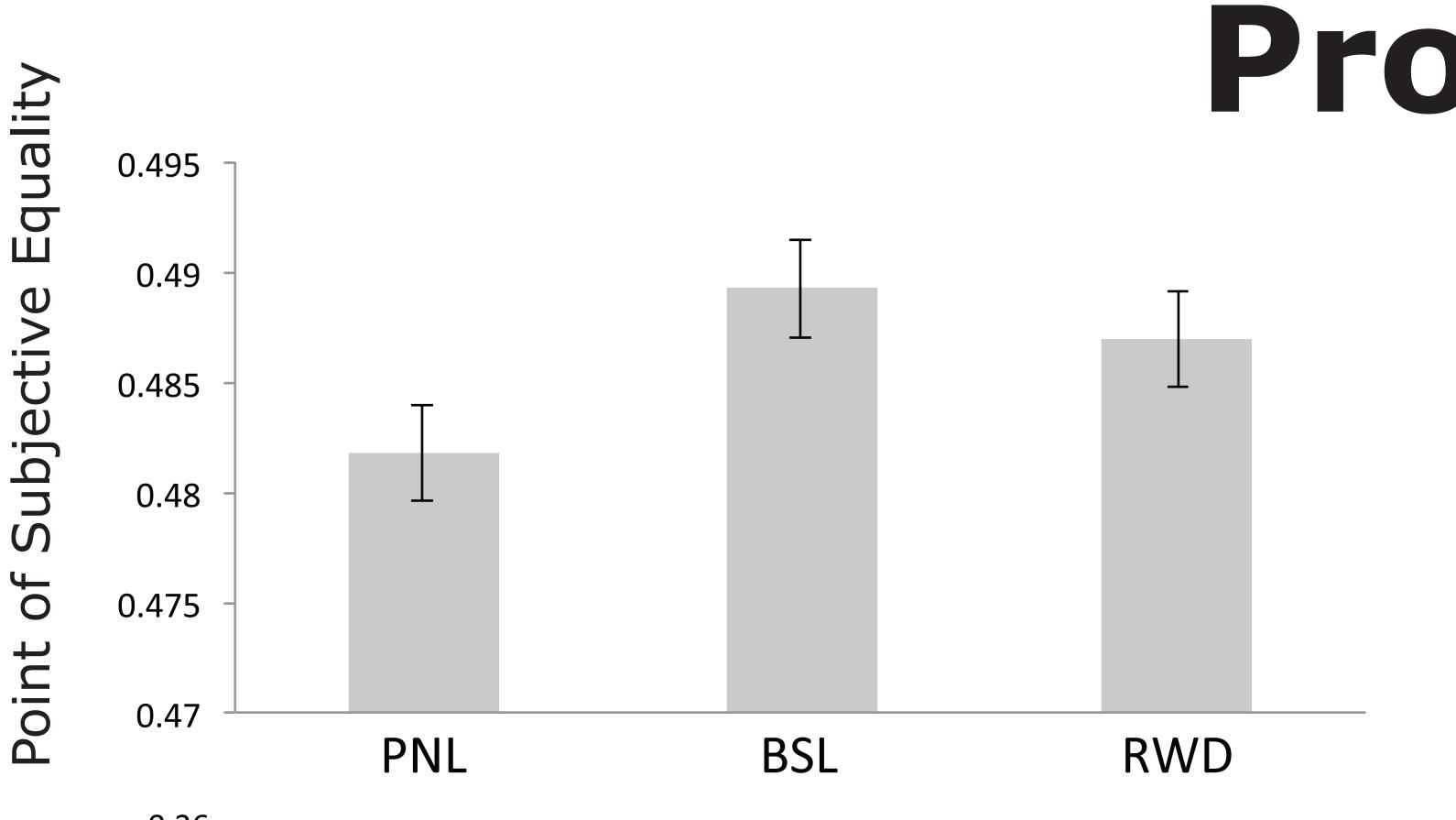
Go Response Times

Increasing the penalty for incorrect responses caused key presses on Go trials to happen later than the baseline and reward blocks ($F[2,46] = 5.86$, $p < 0.0001$).

Proactive Stopping

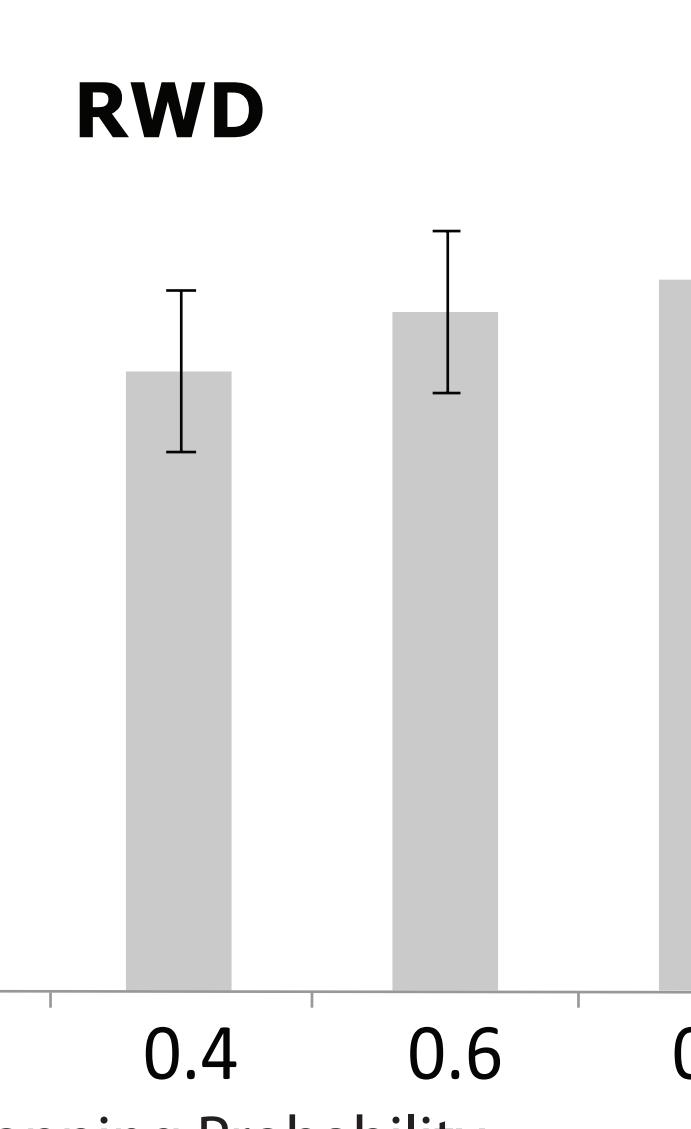
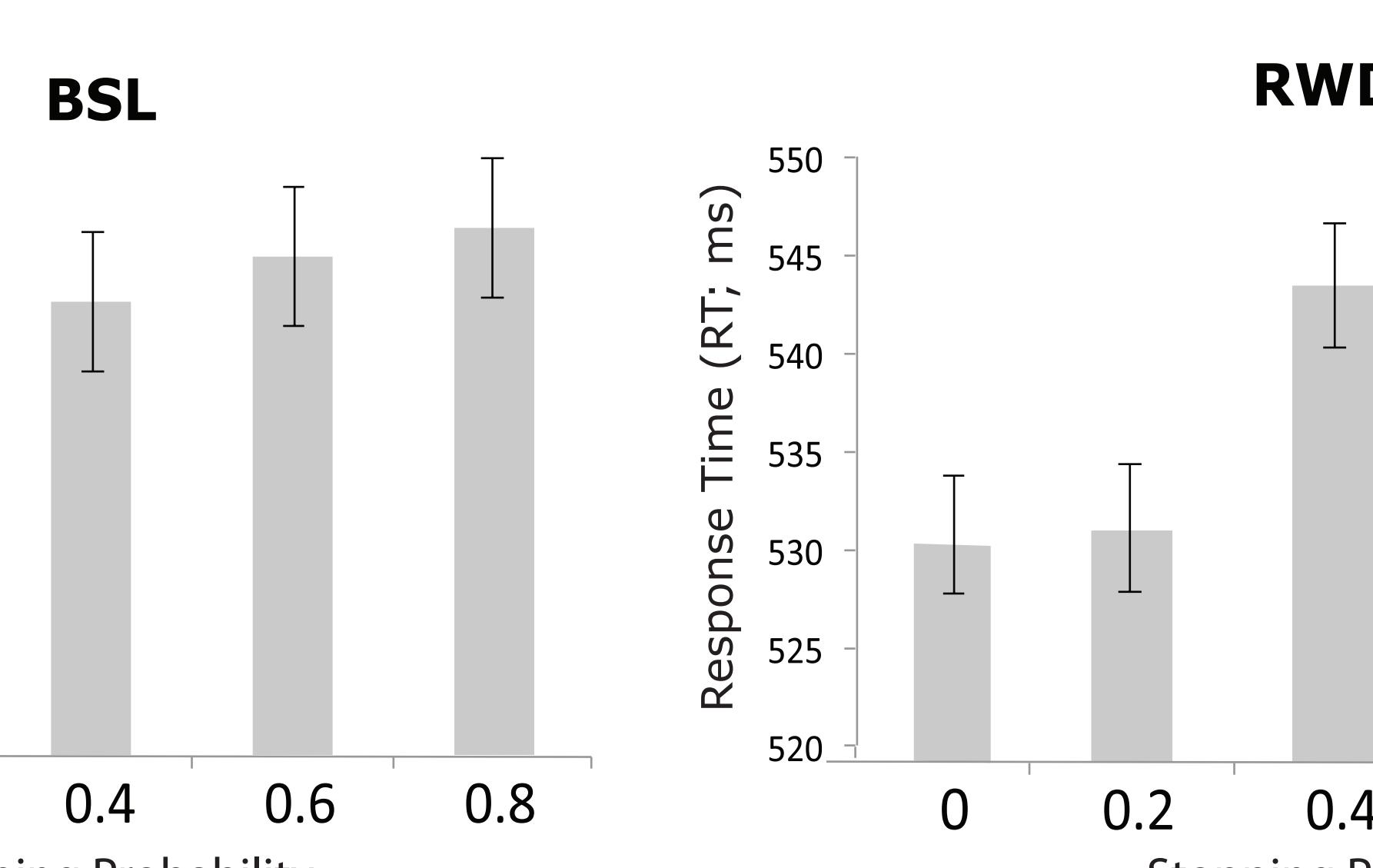
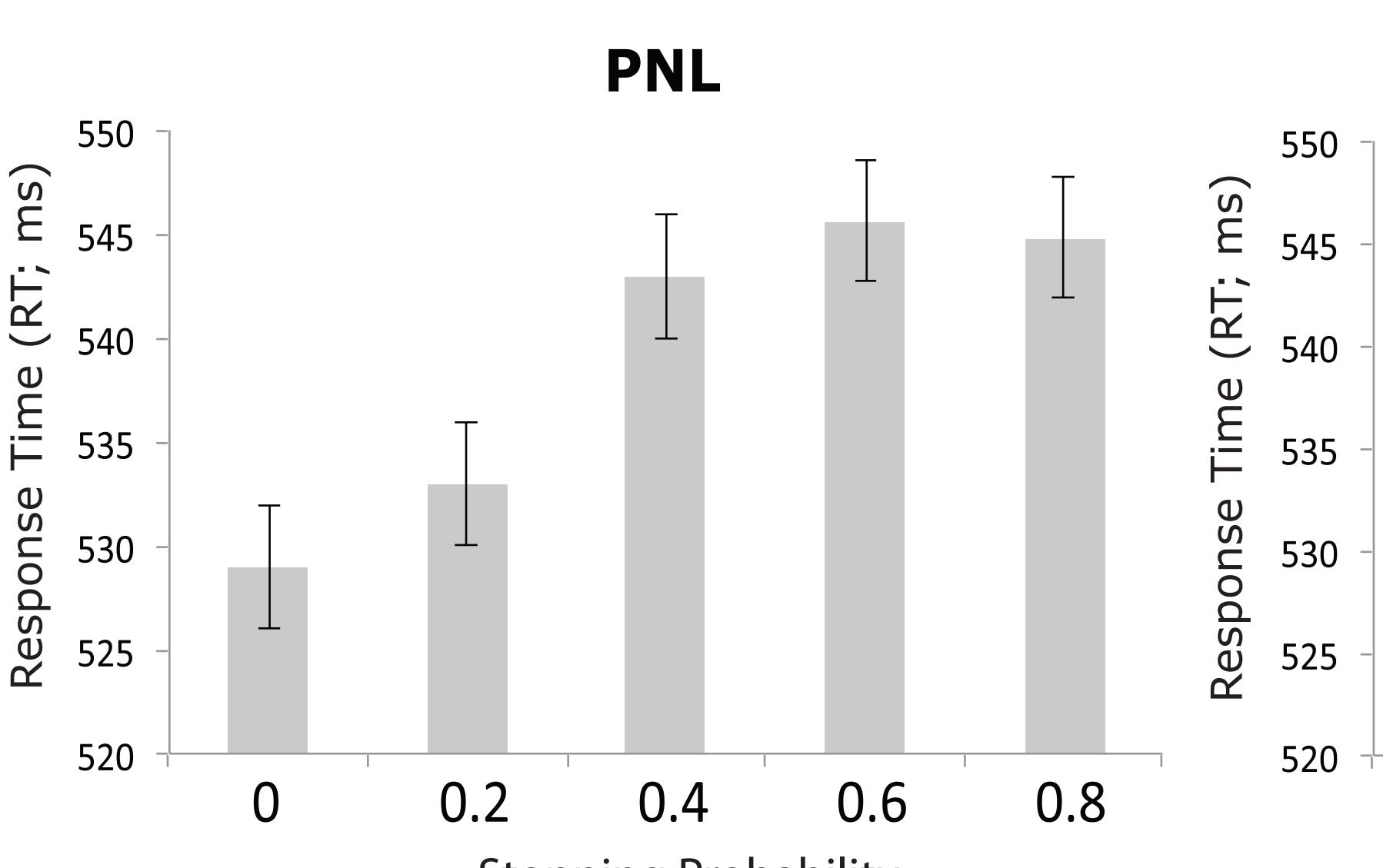
Stopping Means

Increasing the penalty for incorrect responses and reward for successful stopping did not affect the PSE compared to the baseline trials ($F[2,46] < 1$).

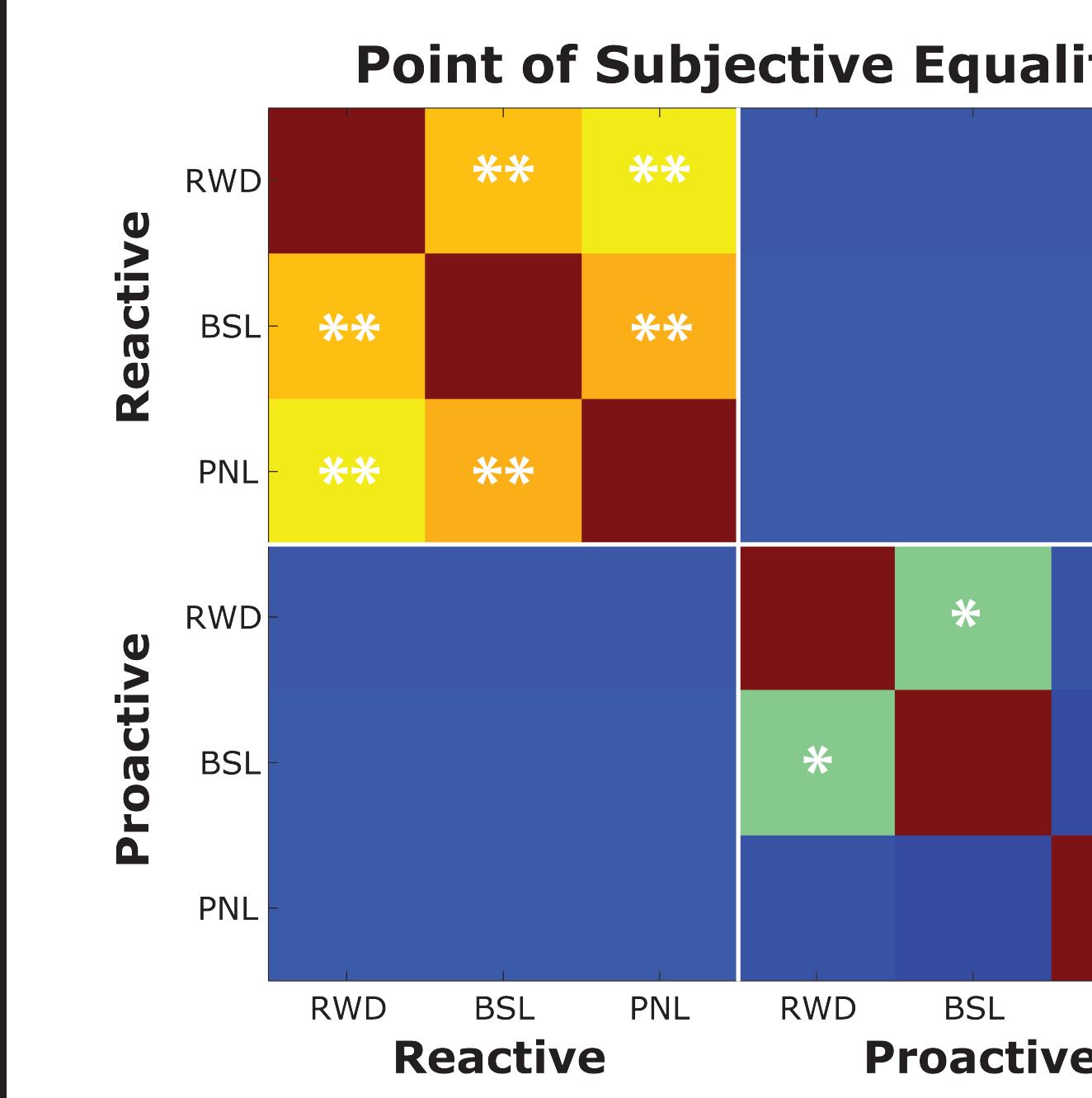


Go Response Times

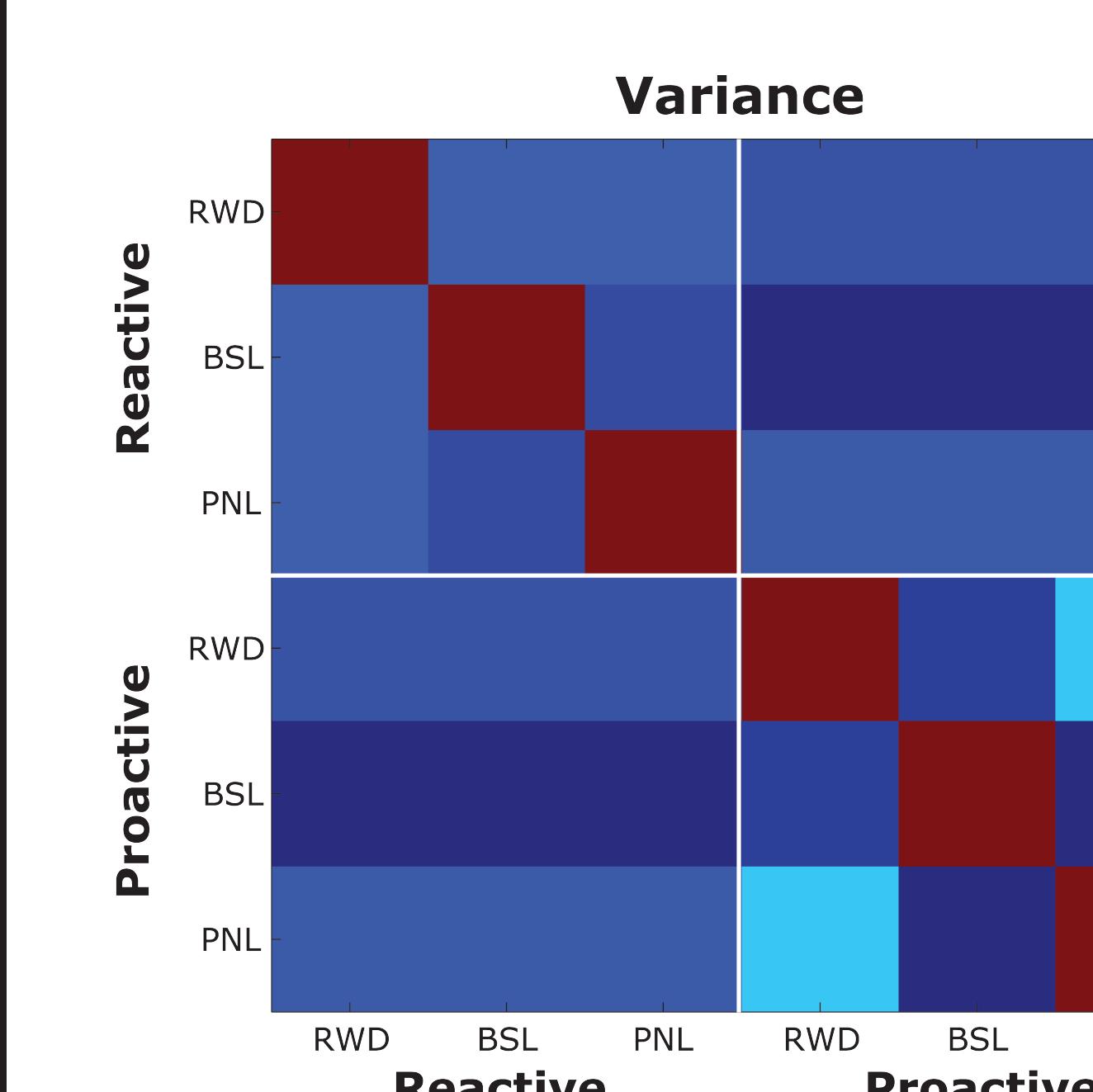
Go Trial response times were consistently longer for cues with higher probabilities of stopping. However, increasing the penalty for incorrect responses and reward for successful stopping did not affect Go Trial response times compared to baseline trials ($F[2,46] = 1.05$, $p = 0.36$).



Correlations



The PSE for reactive stopping was highly reliable across reward conditions.



Stopping precision (i.e., variance) was not correlated across either reward conditions or experiment type.

Summary

- For reactive stopping, increasing the penalty for making an inhibition error (i.e., making a key press when you shouldn't) delays the stopping response relative to baseline trials.
- Reactive stopping abilities are highly consistent across conditions.
- Proactive stopping is not modulated significantly by reward context.
- Proactive stopping appears to be independent on a trial-by-trial basis and is uncorrelated across condition or with reactive stopping abilities.

Conclusion

Proactive and reactive stopping abilities are independent processes that are differentially influenced by motivation conditions.

References

- Haber SN, Knutson B (2010) The reward circuit: linking primate anatomy and human imaging. *Neuropsychopharmacology* 35:4-26.
 Leotti LA, Wager TD (2009) Motivational influences on response inhibition measures. *Journal of Experimental Psychology: Human Perception and Performance* 36(2):430-447.
 Logan GD, Cowan WB (1984) On the ability to inhibit thought and action: A theory of an act of control. *Psychological Review* 91(3):295-327.