

Anger-Guilt Cycle: A Theoretical Model of Dynamic PFC-Basal Ganglia Dysregulation and Repair

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INTRODUCTION & AIM

A **limitation in current neuroscience** is the lack of a dynamic, real-time neurocircuitry account that explains the transition from acute stress to impulsive action and the subsequent shift into guilt-driven repair. While **we understand** the individual roles of the prefrontal cortex (PFC) in regulation and the amygdala in emotional signaling, existing models often treat these as static states rather than a fluid sequence. Specifically, science struggles to map the precise "mismatch" that occurs when PFC function restores and evaluates an impulsive act against internalized social rules. This gap makes it difficult to pinpoint exactly how neurochemical clearance rates and individual learned histories interact to determine whether a person remains in a state of aggression or pivots toward social reconciliation.

Aim: To establish a novel theoretical model of stress-mediated PFC dysregulation that maps the transition from acute stress into impulsive action and subsequent guilt-driven repair.

METHOD

The proposed method integrates existing neurobiological data into a dynamic sequence of PFC-Basal Ganglia dysregulation:

- **Stimulus Appraisal:** The process is initiated by salient environmental stimuli, which the amygdala appraises based on the individual's past associative learning.
- **Neurochemical Suppression:** This appraisal triggers acute anger, activating the SAM/HPA axes and elevating catecholamines that physically suppress Prefrontal Cortex (PFC) activity.
- **Impulsive Selection:** Due to the loss of integrative PFC input, the striatum (Basal Ganglia) selects an action based on immediate stimuli and reinforced behavioral patterns rather than long-term consequences.
- **Functional Restoration:** As neurochemicals clear and PFC function is restored, the renewed projections evaluate the impulsive act against internalized social rules.
- **Reparative Bias:** This cognitive mismatch generates guilt, which subsequently biases the striatum toward a reparative action (e.g., apology) informed by learned strategies for social reconciliation.
- **Learned Individuality:** The entire process is critically shaped by the individual's learned history, where past associative learning determines both the initial action selection (e.g., a tendency toward verbal aggression) and the specific strategies used for guilt-driven reconciliation (e.g., learned apology styles).

RESULTS

□ The Neurochemical Sequence of Dysregulation and Repair:

- **PFC Impairment:** High levels of catecholamines (norepinephrine and dopamine) impair Prefrontal Cortex cognitive regulation via α -1 adrenergic and D1 dopaminergic receptors, causing a loss of top-down behavioural control.
- **Neural Decoupling:** Connectivity analyses show decreased functional coupling between the medial PFC and emotion-processing regions (amygdala/striatum) during anger provocation, which directly correlates with reactive aggression.
- **Guilt Signature:** As neurochemical balance restores, a distributed neural signature of guilt emerges—centered in the dorsomedial PFC and anterior midcingulate cortex—which predicts the motivation for reparative behaviour.

□ The Fear-Regret Cycle: Dysregulation of Intent

The model's results further indicate a parallel sequence for fear-driven impairment:

- **PFC-Driven Intent:** During calm states (high PFC activation), individuals establish logical plans to overcome specific fears or phobias, relying on top-down cognitive control.
- **Acute Fear Hijack:** Upon encountering a fear stimulus, the amygdala triggers a surge of stress neurochemicals that physically impair the PFC, effectively "silencing" the logical plan.
- **Sub-Optimal Decision Making:** Without PFC guidance, the individual is unable to execute their intended strategy, leading to avoidance or panic-based actions driven by the striatum and survival circuits.
- **Restoration and Regret:** As the threat passes and the PFC restores, the individual evaluates their performance against their original plan; the resulting cognitive mismatch generates regret (e.g., "Why couldn't I follow my plan?").

DISCUSSION & CONCLUSION

This suggests that **what we see as a character flaw** of self-control is actually a temporary PFC impairment caused by acute neurochemical surges that physically de-link logical oversight from the striatal action-selection centers. Therefore, in those high-stress scenarios, we could focus on stopping the PFC impairment itself—rather than simply blaming a lack of willpower. By maintaining prefrontal integrity during the peak of the stress response, the individual can prevent the "hijack" that leads to impulsive aggression or fear-driven failures, ultimately bypassing the subsequent cycle of guilt and regret.

Conflicts of Interest: None declared.