Bidirectional Benefits: Inter-Brain Synchronization and Role-Specific Neural Signatures in Interpersonal Emotion Regulation

Yunkai Yang[1], Jinxin He[1], Xiaowei Jiang[2], Yanan Chen[1]
1 Institute of Psychology and Behavior, Henan University, Kaifeng 475001, China
2 School of Computer Science, University of Technology Sydney, Ultimo NSW 2007, Australia

Introduction

Interpersonal emotion regulation is not a one-way process. Although prior work has mainly focused on how regulators influence targets, real-world regulation may benefit both dyad members. We asked how role-specific prefrontal mechanisms and interbrain synchronization jointly support these bidirectional benefits during cognitive reappraisal and distraction. Using fNIRS hyperscanning and multivariate pattern analysis (MVPA), we tested whether distributed interbrain patterns encode both regulation strategy and regulatory success.

Experimental Design

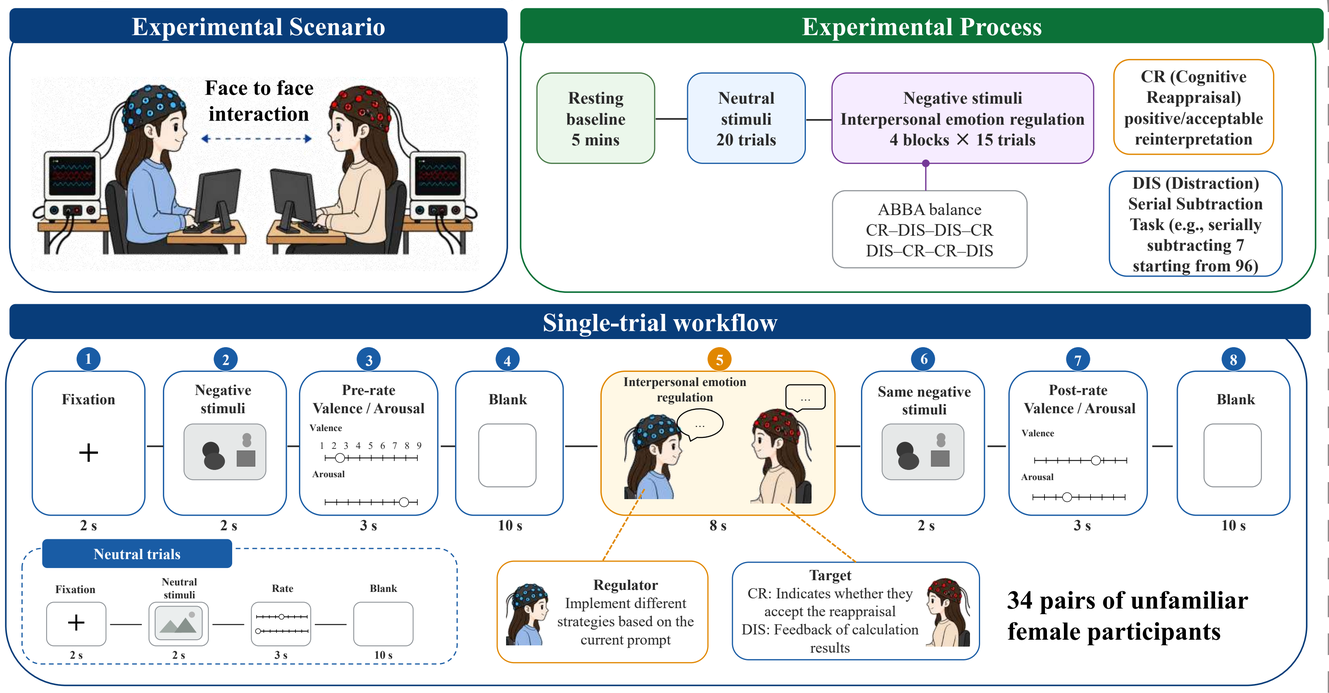


Figure 1. Experimental Design.

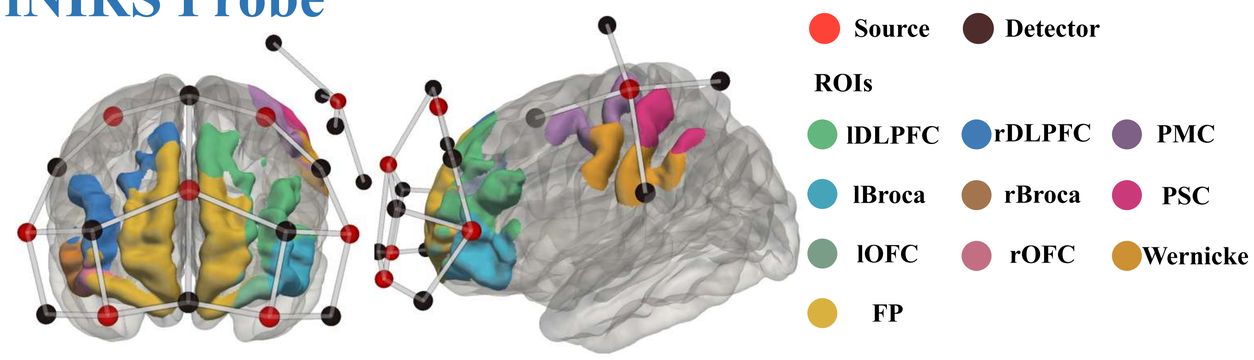


Figure 2. fNIRS probe placement and Regions of Interest (ROIs).

Results

Behavioral Findings

Both cognitive reappraisal (CR) and distraction (DIS) improved emotional valence for both regulators and targets, supporting the idea of bidirectional benefits in interpersonal emotion regulation. Importantly, CR produced greater valence improvement than DIS, suggesting that meaning-based interpersonal regulation is more effective than attention-based distraction in this task. Regulators also reported overall higher valence than targets, consistent with a possible regulator's gain during active regulatory engagement.

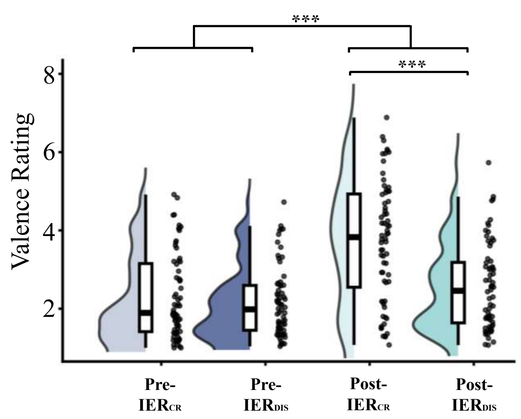


Figure 3. Interaction of Time and Strategy on Valence Ratings.

Single-Brain Findings

Prefrontal activation showed a clear Role × Strategy pattern. Regulators showed stronger engagement of high-order control and social-cognitive regions, including the frontopolar cortex and orbitofrontal cortex, especially during CR. In contrast, targets showed stronger right-lateralized activation, particularly in the right OFC and right Broca's area, during DIS.



Figure 4. Single-Brain Activation Patterns Across Roles and Strategies in Key ROIs.

This suggests that cognitive demands were distributed differently across roles: regulators carried the burden of generating and guiding reappraisal, whereas targets recruited more executive resources when actively performing distraction.

Inter-Brain Findings

Distributed IBS patterns successfully decoded both the IER strategy and regulatory success for both dyad members. This indicates that successful IER is not only reflected in isolated brain activation, but also in the configuration of neural coordination between two brains. Feature contribution analyses further showed that synchronization originating from the regulator's frontopolar cortex was especially important, suggesting that the regulator's FP may function as a social alignment hub that organizes dyadic regulation.

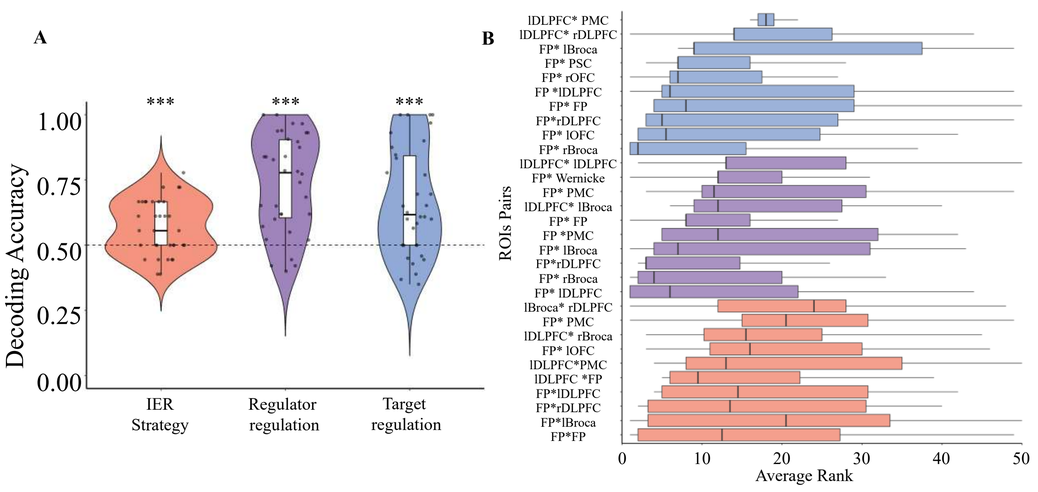
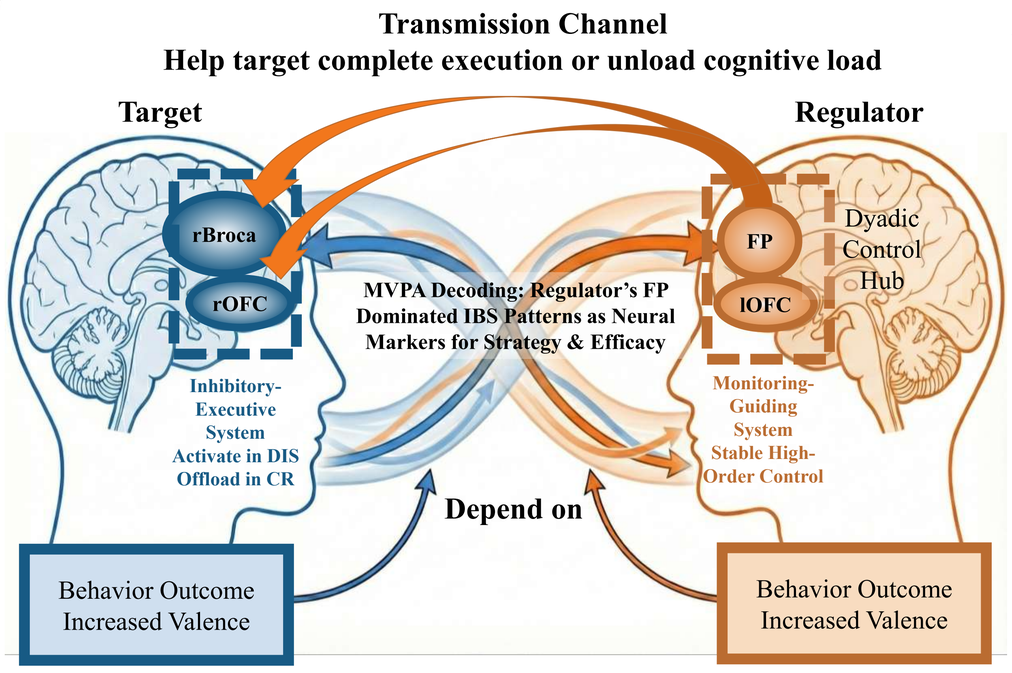


Figure 5. Multivariate Pattern Analysis (MVPA) Decoding Results from IBS Data.



Discussion

The findings support a bidirectional neural model in which successful interpersonal emotion regulation emerges from the integration of role-specific neural specialization and dyad-specific interbrain coordination. At the individual level, regulators and targets recruit different neural resources depending on strategy and role. At the dyadic level, IBS links these role-specific processes into a coordinated regulatory system. Thus, IER is not simply the regulator changing the target's emotion; rather, it is a dynamic multibrain process in which both partners participate in and benefit from shared emotional alignment.

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Ongoing Extension

Do interbrain features carry information beyond single-brain activation?
Can IBS serve as a stable neural feature for social interaction decoding?
Does the geometry of interbrain network patterns align with trial-level emotional improvement?

