Resting State Neural Activity, Empathy, and Their Association with Internalizing Symptoms

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Introduction

Previous literature has shown variations in resting state neural activity to predict empathic concern (Christov-Moore et al., 2020). The current study aimed to investigate **whether distinct patterns of resting state neural activation** in the dorsolateral prefrontal cortex (DLPFC) **are predictive of empathy and internalizing symptoms**. Participants' neural activation was measured by use of a functional near-infrared (fNIRS) device which measures changes in blood oxygenation at 16 locations across the DLPFC (see Figure 1). Participants' resting state neural activity was measured for two minutes, after which the **Frith-Happé Animations** was administered (see Figure 2), which measures **Theory of Mind (ToM),** an important cognitive component of empathy. We hypothesized that resting state neural activation would be associated with both empathic processing and internalizing symptoms (see Figure 3). Additionally, we expected variations in empathic processing to be associated with internalizing symptoms.

The objectives of the current study were as follows:

1. To determine whether patterns of resting state neural activation are associated with differences in empathic processing.
2. To determine whether patterns of resting state neural activation are associated with internalizing symptoms.
3. To examine how empathic processing may mediate and/or moderate the association between resting-state neural activation and internalizing symptoms.
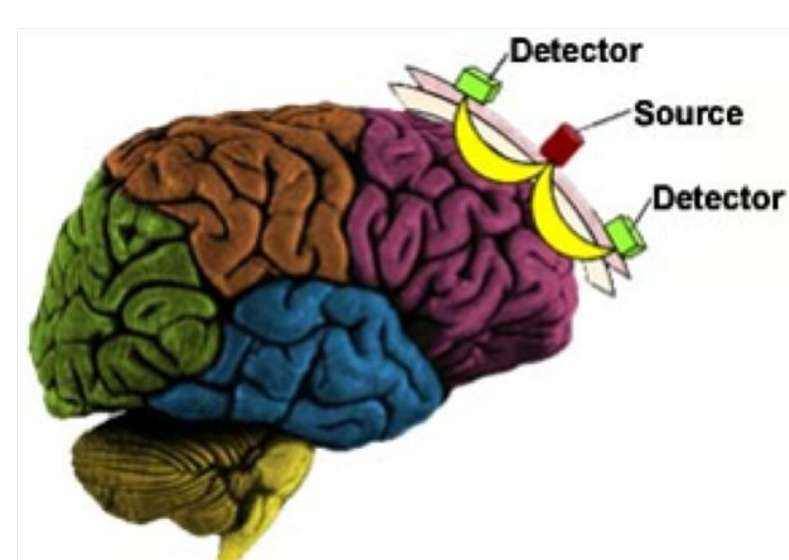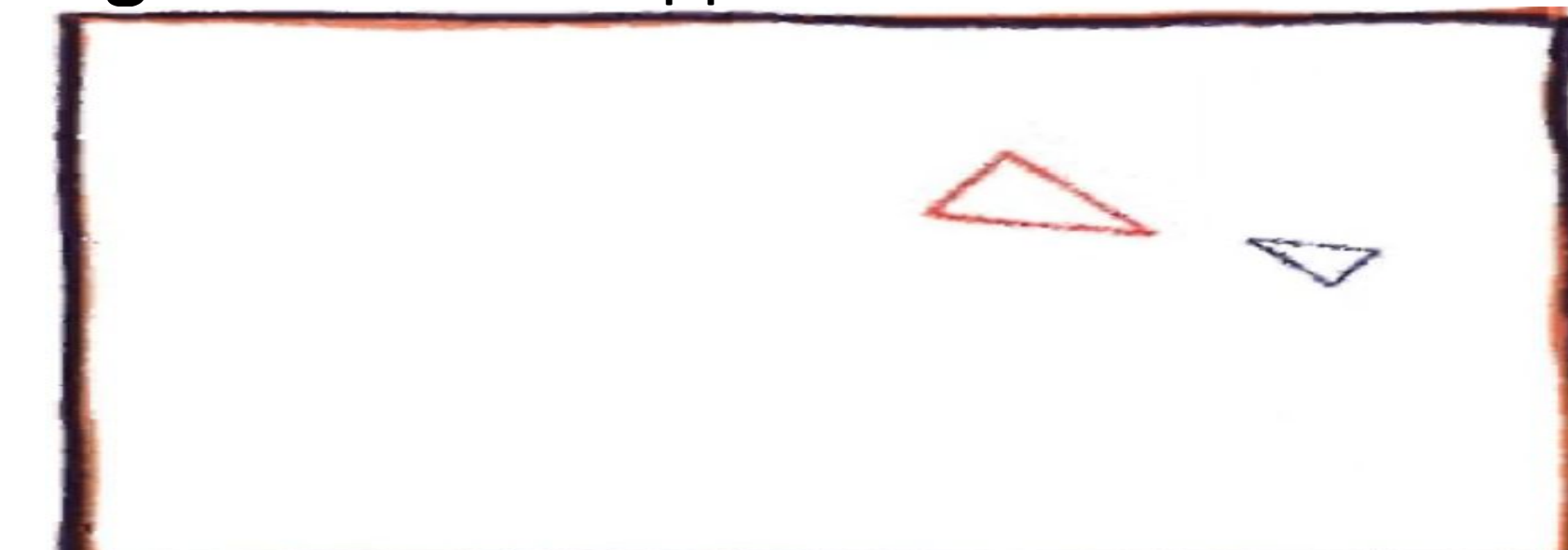
Figure 1. fNIRS Apparatus

Figure 2. Frith-Happé Animations

Method

Participants were recruited through the online Sona Systems participant pool. 158 psychology majors at SUNY Geneseo were recruited. Their ages ranged from 17 to 36 years old with an average age of 19 years old. The sample contained 25 males and 133 females.

Participants first were connected to the fNIRS brain imaging device). fNIRS uses infra-red light to measure changes in blood oxygenation across the DLPFC. Resting state neural activity was recorded for two minutes before administering the Frithe Happé animations to assess empathy processing. Following the task, participants completed a self-report questionnaire related to empathy and well-being.

Frith-Happé Animations: ToM assesses one's ability to understand the mental states of another person. This skill is a prerequisite component of empathy. ToM was assessed using the Frith-Happé Animations Test, consisting of 12 videos in which animated triangles move in a way that indicates either a mental interaction, physical interaction, or no interaction (White et al., 2011). Participants were asked to categorize the type of interaction depicted in each video. Animations correctly identified as ToM had follow up questions about the "mental states" of each triangle.

Self-report measures of empathy and well-being: After completion of the Frith-Happé task with the fNIRS, participants completed a brief questionnaire containing scales that assessed empathy reactions, anxiety, depression, happiness, and self-harm.
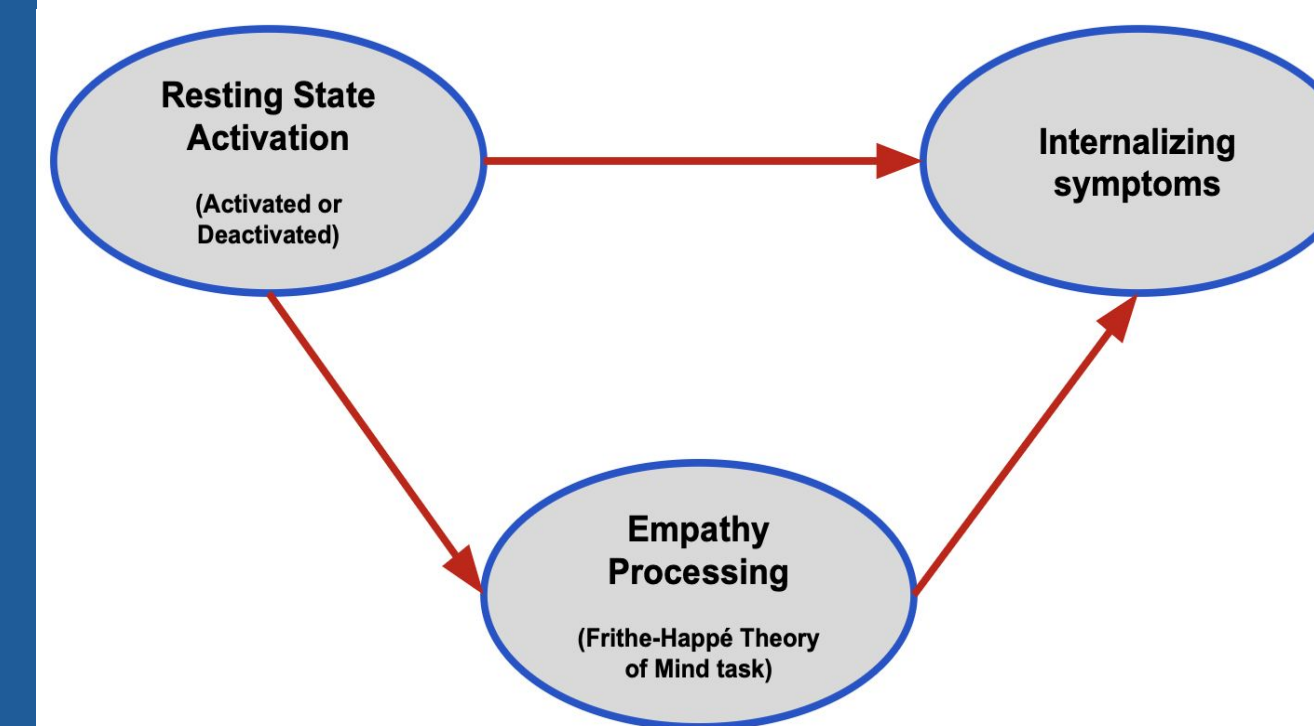
Figure 3. Model

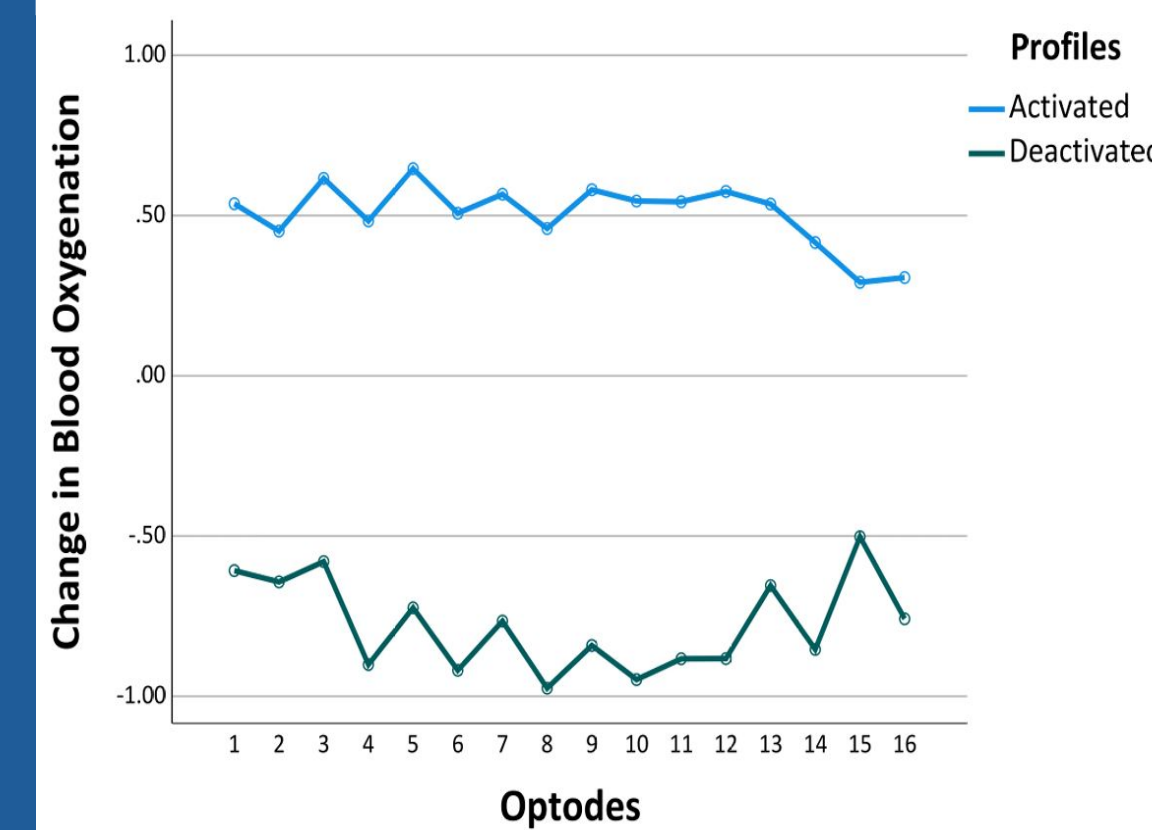

Figure 4. Resting State Profiles
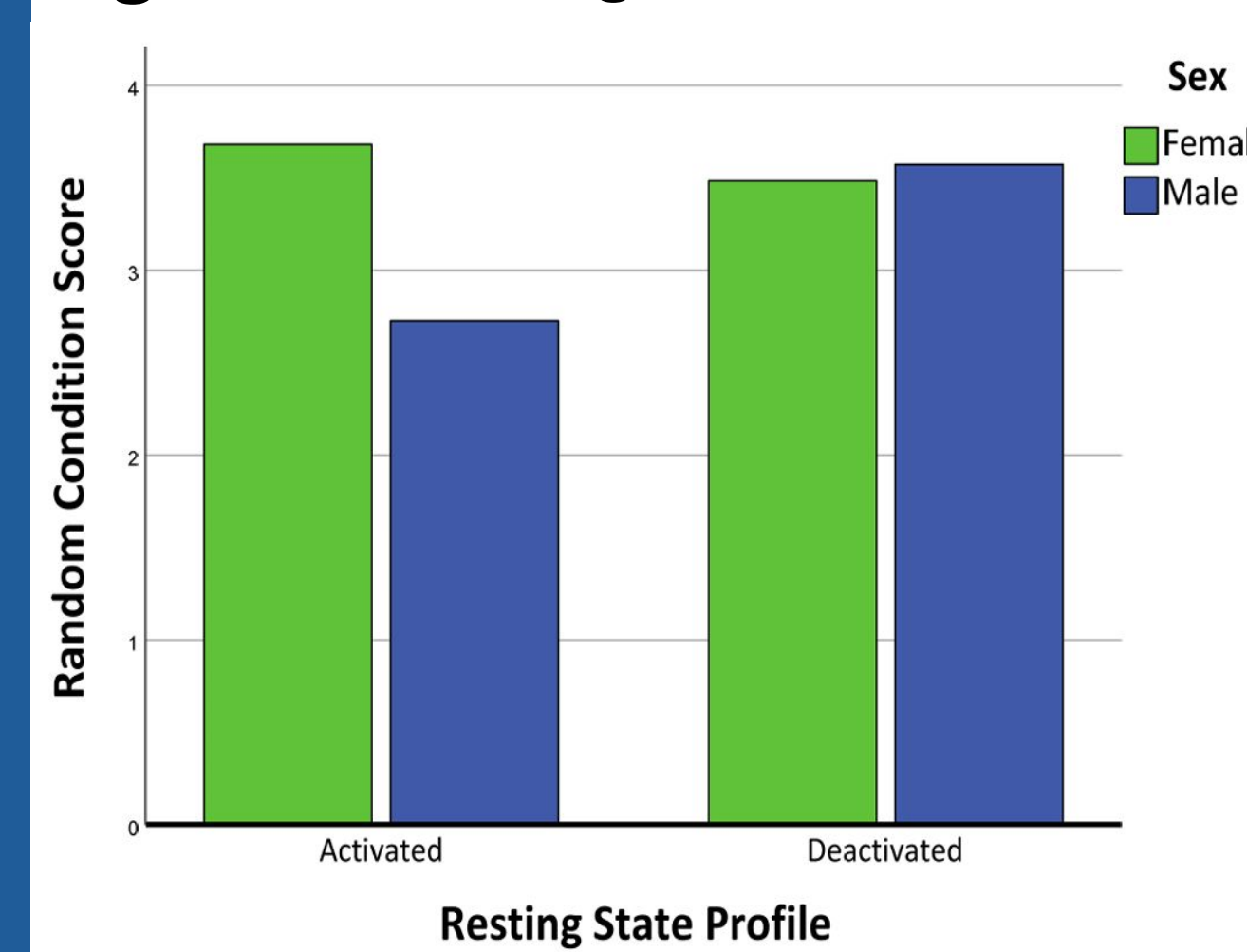

Figure 5. Resting State Profile x Sex

Results

Resting State Profiles
Cluster analysis identified two unique **patterns of resting state neural activity across the DLPFC** – an *activated* group displaying increased neural activation, and a *deactivated* group displaying decreased neural activation (see Figure 4).

Objective 1: Resting State activation and empathy processing
MANOVA revealed a significant interaction effect in predicting accurate processing of random interactions. *Sex modified the effect of resting state activation.* Specifically, **males who were activated** during resting state pattern were significantly worse at identifying random interactions in the Frith-Happé task compared to deactivated males: $F(1,154) = 9.79$, $p = .002$ (see Figure 5). Females were unaffected by resting state activation.

Objective 2: Resting State Profiles and Psychopathology
MANOVA revealed that profiles of resting state activation were significantly associated with levels of **anxiety**, **depression**, and **happiness** relative to the deactivated group (see Table 1).

Objective 3: The Role of Empathy Processing in the Relationship between Resting State Activation and Internalizing Symptoms
When MANOVA was used to look at the joint effects of resting state activation and empathy processing on internalizing symptoms, only empathy processing had a significant: $F(5,150) = 2.32$, $p = .046$. Specifically, *correctly identifying mental interactions* uniquely predicted levels of depression: $F(1,154) = 8.42$, $p = .004$ (see Table 2).

Table 1. Resting State Profiles and Symptoms

	Resting state	Avg Self-Report Score
Anxiety	Activated	16.602
	Deactivated	12.536
Depression	Activated	17.417
	Deactivated	12.154
Happiness	Activated	17.184
	Deactivated	19.585

Table 2. Accuracy in Identifying Mental interactions and Self-Reported Depression

Mental Interactions		Mean Self-Report Score
Depression	High-scoring	17.378
	Low-scoring	12.307

Conclusions

1. Resting state neural activation across the DLPFC was predictive of empathy processing, but its effect was modified by sex. Males who were activated during resting state seemed to be a disadvantage when trying to process random interactions.
2. Resting state activation was associated with internalizing symptoms. Individuals who showed elevated resting state activation across the DLPFC reported significantly **higher levels of anxiety and depression, and lower levels of happiness.**
3. The evidence is consistent with empathy processing mediating the relationship between resting state activation and internalizing symptoms. When empathy processing was accounted for, resting state activation no longer was significantly associated with internalizing symptoms. This finding is consistent with previous research by Yan, et al. (2021) indicating that heightened empathy is correlated with elevated levels of depression.

Taken together, these findings indicate that individual differences in resting state neural activation of the DLPFC may be part of a pathway to internalizing symptoms. In particular, resting state neural activation may influence how people interpret and perceive the internal states of others in ways that may make them vulnerable to internalizing disorders.