Response Inhibition in Adolescents is Moderated by Brain Connectivity and Social Network Structure

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Abstract:

Adolescents' daily experiences navigating and managing complex social relationships with multiple distinct communities influence how they utilize different cognitive strategies or motivational resources in order to engage in self-control. This is particularly important given evidence that adolescents tend to have weaker activation in brain regions typically recruited during self-control. Here we test whether activity in social brain systems (self-processing and mentalizing systems) can be used to facilitate successful cognitive control, and whether adolescents' social networks influence the brain networks they recruit to successfully regulate their behavior. We measured 62 adolescents' brain activation while they completed a Go/No-Go response inhibition task. We also collected information about adolescents' social networks. We find that recruitment of social brain systems (in particular the self-processing system) is associated with better response inhibition in adolescents, especially for adolescents who have weaker activation in response inhibition systems. Moreover, adolescents with larger social networks with more distinct communities show stronger relationships between brain systems and response inhibition. Collectively, our results provide insight into how brain systems facilitate cognitive control in adolescents.

Keywords: response inhibition, adolescents, social networks

Introduction

Peer influence is a pervasive factor that strongly influences adolescent behavior[1]. Self-control can help buffer adolescents from negative peer influence[1], but emerging work shows that adolescents' social networks can also influence their self-control[2]. This relationship is particularly important because both negative peer influence and weak self-control contribute to behavioral issues during adolescence[1,3,4]. Moreover, adolescents typically show a more diffuse brain activation pattern, including weaker activation in brain regions associated with response inhibition when engaging in tasks that require self-control[5]. While some evidence suggests that behavioral issues in adolescents are at least in part due to this pattern of weaker activation in control systems and more distributed activation elsewhere in the brain[4], it is also possible that adolescents compensate for weaker control systems by leveraging social resources or recruiting other cognitive systems.

Recent work in network neuroscience suggests that successful performance on many cognitive tasks requires coordinated action across multiple brain regions and brain systems[6]. Furthermore, social relationships and individuals' position in their social network shape how individuals' brains process information[7]. A network neuroscience framework that also takes into account social context might yield important insights into how individual differences in brain systems associated with response inhibition or social processing might help or hurt response inhibition.

In the current study, we use a network neuroscience approach to examine patterns of activation and connectivity across networks of brain regions. Sixty-two adolescents completed a Go/No-Go response inhibition task while their brain activity was measured in an MRI scanner, and we used Neurosynth to define three

systems involved in response inhibition, self-processing, and mentalizing (Figure 1A). We also collected information about adolescents' social networks. We anticipate that social brain systems, including brain systems involved in self-referential processing and mentalizing, should facilitate response inhibition, especially for adolescents with weaker executive function systems. Importantly, these effects should be moderated by social network structure, including network size, number of communities, and network modularity.

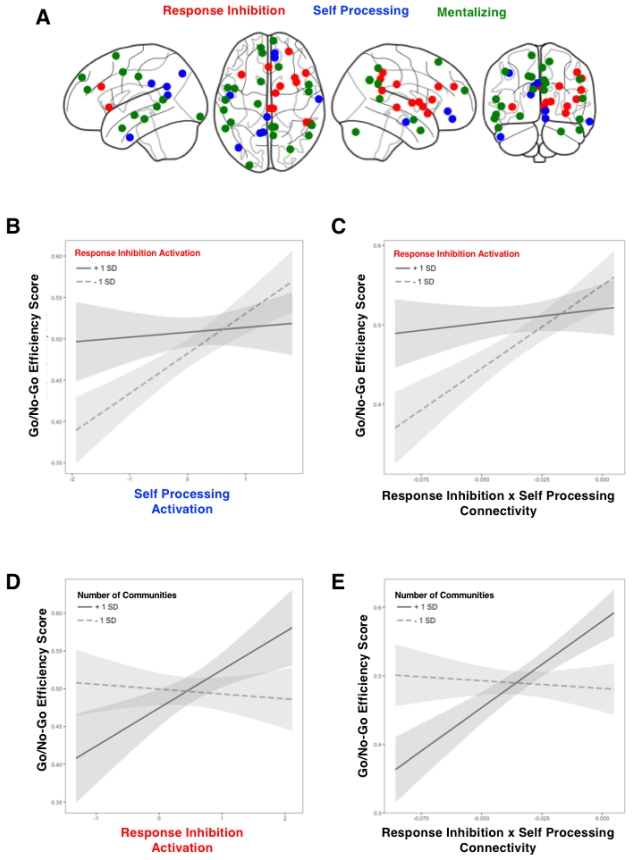

Figure 1: Role of brain system activation and connectivity in Go/No-Go task efficiency.

We show here for the first time that adolescents who have weaker response inhibition activation still perform well on the Go/No-Go task if they have stronger activation in self-processing (Figure 1B) and mentalizing systems and greater connectivity between the self-processing and response inhibition system during the task (Figure 1C). Furthermore, we find that the relationship between brain systems and response inhibition is influenced by adolescents' social networks. We find that adolescents with larger, more modular social networks recruit more diverse brain systems in order to successfully inhibit prepotent responses (Figure 1D and 1E).

Taken together, our research shows that more distributed patterns of brain activation in adolescents reflects their real-life social network, and these more distributed brain activations might reflect an adaptive regulatory response to adolescents' social environment. It is possible that adolescents' daily experiences navigating and managing complex social relationships with multiple distinct communities influence how they utilize different cognitive strategies or motivational resources in order to complete cognitive tasks such as response inhibition.

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