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The application of neuroimaging to social inequity and language disparity: A cautionary examination

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ABSTRACT

In the nascent field of the cognitive neuroscience of socioeconomic status (SES), researchers are using neuroimaging to examine how growing up in poverty affects children's neurocognitive development, particularly their language abilities. In this review we highlight difficulties inherent in the frequent use of reverse inference to interpret SES-related abnormalities in brain regions that support language. While there is growing evidence suggesting that SES moderates children's developing brain structure and function, no studies to date have elucidated explicitly how these neural findings are related to variations in children's language abilities, or precisely what it is about SES that underlies or contributes to these differences. This issue is complicated by the fact that SES is confounded with such linguistic factors as cultural language use, first language, and bilingualism. Thus, SES-associated differences in brain regions that support language may not necessarily indicate differences in neurocognitive abilities. In this review we consider the multidimensionality of SES, discuss studies that have found SES-related differences in structure and function in brain regions that support language, and suggest future directions for studies in the area of cognitive neuroscience of SES that are less reliant on reverse inference.

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1. Introduction

Recent rapid growth in human neuroimaging is providing the opportunity to examine the relations among socioeconomic status (SES), language development, and brain development, with the ultimate goal of being able to address troubling social inequities more effectively. In this paper we review studies that use neuroimaging to assess the impact of SES on neural features of children's developing linguistic competence. SES encompasses occupation, income, and education and is typically assessed as either a weighted average of these measures, such as the commonly used Hollingshead Index (HI;Hollingshead, 2011), or one of these measure individually. Family SES has been consistently related to children's early language environments (Hart and Risley, 1995; Hess and McDevitt, 1984; Hoff, 2003; Rowe, 2008), as well as to their linguistic trajectories and outcomes (Hart and Risley, 1995; Fernald, Marchman, and Weisleder, 2012). Researchers have begun to use methods from cognitive neuroscience to examine the effects of SES on neural structure and function, particularly in the context of language development. These studies in the growing area of the cognitive neuroscience of SES focus specifically on neural aspects of language development, assessing the relation of SES to the structure and function of brain regions that support language comprehension and

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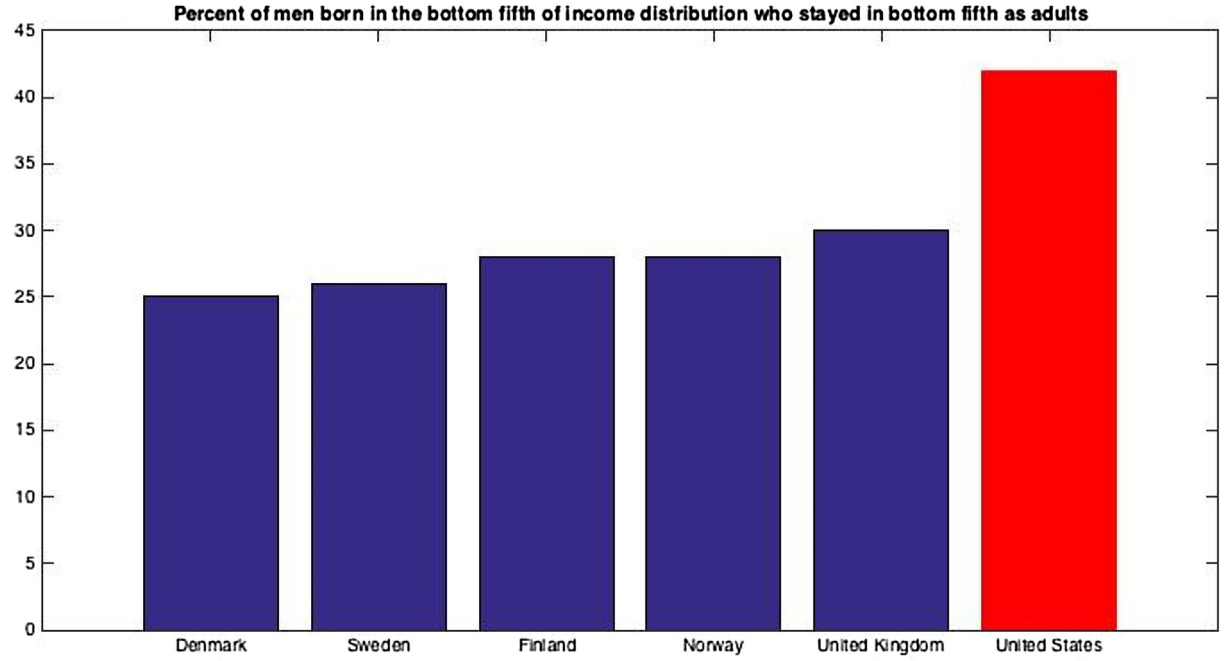

Fig. 1. Based on data presented by Isaacs et al., 2008.

production. Importantly, however, although many of these studies are methodologically sound, they rely on reverse inference in drawing conclusions about children's development. Reverse inference refers to the practice within cognitive neuroscience of making inferences about people's mental states based on the presence of activation within a particular brain region (Poldrack, 2011). The use of reverse inference in this context of the cognitive neuroscience of SES has the unfortunate effect of leading researchers to interpret associations between higher levels of SES and the structure and function of brain regions that support language as prototypic of optimal development, even in the absence of behavioral evidence for such an interpretation.

Family SES can be conceptualized as a measure of children's opportunities. Caregivers who are less educated may not be as equipped to help their children excel in school; those without sufficient money may not be able to purchase extra resources like books and toys; those who work particularly intensive jobs may not have the time or energy to provide the same level of social and emotional support. While education, income, and occupation are interrelated, it is likely that these variables contribute differentially to distinct early childhood experiences (Duncan and Magnuson, 2012). Indeed, there is no clear consensus in the literature about what indices should be used to categorize a family as "lower-SES." Certainly, there is considerable variability within SES groups, such that children whose families come from similar backgrounds may have exposure to very different sets of opportunities. Still, researchers have consistently found that lower-SES children fare more poorly on a variety of outcome measures. The United States in particular has low rates of relative mobility in comparison with many other developed countries (Fig. 1); thus, children who are born into poverty are more likely to stay in poverty as adults than is the case in many other developed countries (Isaacs et al., 2008). The majority of studies conducted to date examining SES have therefore focused on the United States, although these issues clearly warrant further international research. The dominant view among researchers in the cognitive neuroscience of SES is that these differences in children's environments affect brain development and, ultimately, cognitive functioning and skills (Johnson et al., 2016). These studies often rely on a model based on animal literature indicating that rodents raised in severe social deprivation ultimately develop fewer and less efficient synaptic connections and abnormal stress reactivity (McLaughlin et al., 2014).

It is important to recognize, however, that documenting the presence of SES-associated neural effects alone is not sufficient to support this formulation. While lower-SES children may be deprived of certain enriching experiences, they may also have other experiences which are less often considered. For example, researchers have found levels of SES to be related to individual differences not only in such constructs as children's vocabulary size and reading skill, but also in the ways families use language (such as abiding by culturally-prescribed discourse rules), first language (such as learning another language before English), and bilingualism (Hakimzadeh and Cohn, 2007; Wyatt, 1995). These potential confounds complicate the interpretation of SES-related differences in neural function and structure in regions that support language. While it is difficult to avoid reverse inference altogether in neuroimaging studies (Poldrack, 2011), we believe that a more critical investigation of language is needed to advance the cognitive neuroscience of SES.

To date, studies of the cognitive neuroscience of SES have been important in demonstrating that there are significant differences between children from low- and high-SES families in neural structure and function. In addition to examining potential language differences, these researchers have also examined executive function and emotional processing. Many of these studies, however, have not explicitly linked the neural differences they documented to environmental or cognitive variables. Instead, they have used children's SES as a proxy for these constructs, making an assumption that children from low-SES backgrounds grow up in sub-optimal environments and have reduced cognitive skills. In this context, therefore, higher-SES children's brains are viewed as optimal, leading to interpretations of SES-related group differences in neural function and structure as reflecting a deficit in lower-SES children.

In this review we focus on language development as an exemplar of this phenomenon within the field of the cognitive neuroscience of SES. Advances in technology now allow researchers interested in language to assess more systematically how chil-

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