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Review

A compensatory role for declarative memory in neurodevelopmental disorders

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ABSTRACT

Most research on neurodevelopmental disorders has focused on their abnormalities. However, what remains intact may also be important. Increasing evidence suggests that declarative memory, a critical learning and memory system in the brain, remains largely functional in a number of neurodevelopmental disorders. Because declarative memory remains functional in these disorders, and because it can learn and retain numerous types of information, functions, and tasks, this system should be able to play compensatory roles for multiple types of impairments across the disorders. Here, we examine this hypothesis for specific language impairment, dyslexia, autism spectrum disorder, Tourette syndrome, and obsessive–compulsive disorder. We lay out specific predictions for the hypothesis and review existing behavioral, electrophysiological, and neuroimaging evidence. Overall, the evidence suggests that declarative memory indeed plays compensatory roles for a range of impairments across all five disorders. Finally, we discuss diagnostic, therapeutic and other implications.

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1. Introduction

Not surprisingly, most research on neurodevelopmental disorders has focused on the behavioral and neurobiological abnormalities that characterize them, and on the underlying causes of these abnormalities. However, what remains normal may be as important as what is abnormal. It has long been known that relatively intact circuitry can play compensatory roles in brain disorders – even subsequent to adult-onset lesions, where less plasticity is generally expected than in children. For example, the right hemisphere may compensate for left hemisphere damage (Basso et al., 1989), and spared sensory systems can be employed in the face of sensory deficits, such as Braille reading by the blind.

It has previously been suggested that declarative memory, an important learning and memory system in the brain, may compensate for certain deficits in some neurodevelopmental disorders. In particular, it has been proposed that this memory system can at least partially take over certain functions that normally rely heavily on other systems. Such compensation has been posited for grammatical deficits in specific language impairment (Ullman and Pierpont, 2005), procedural memory impairments in obsessive–compulsive disorder (Rauch et al., 1997), and deficits of theory of mind and of implicit learning in autism spectrum disorder (Frith, 2004; Klinger and Dawson, 2001; Klinger et al., 2007). However, this evidence has not been synthesized or systematically reviewed, within let alone across disorders. Nor has declarative memory-based compensation been examined more broadly, including in related neurodevelopmental disorders and for a broader range of deficits. Thus the nature and extent of compensation by the declarative memory system remains unclear.

Here we present an in-depth examination of the *declarative memory compensation hypothesis*, which posits that declarative memory should play compensatory roles for multiple impairments across disorders, as long as the system remains largely functional. Specifically, we examine whether and how declarative memory plays compensatory roles across a range of deficits (beyond grammar and procedural memory) in several neurodevelopmental disorders that are often comorbid with each other (Bradshaw, 2001; Gillberg, 2010; Goorhuis-Brouwer and Wijnberg-Williams, 1996; Pauc, 2005; Pennington and Bishop, 2009): specific language impairment (SLI; i.e., developmental language disorder), dyslexia, autism spectrum disorder (ASD), Tourette syndrome, and obsessive–compulsive disorder (OCD). Because declarative memory is powerful and flexible in that it can learn and retain multiple types of information, functions and tasks (Eichenbaum, 2012; Squire and Wixted, 2011; Ullman, 2015b), it should be able to support the learning and use of many types of compensatory strategies. Importantly, because this memory system is quite well understood in both humans and non-human animals, elucidating its compensatory roles in neurodevelopmental disorders has the potential to be highly informative, and could lead to therapeutic and diagnostic advances as well as to an increased understanding of the disorders themselves.

The main goals of this paper are to present the declarative memory compensation hypothesis, to lay out clear testable predictions, to review and synthesize existing evidence for these predictions for each disorder, to elucidate gaps and weaknesses that can guide future studies, and to outline potential impacts for basic and translational research.

Below, we first provide a brief review of declarative memory. Next, we show that learning and retention in declarative memory remain largely intact in the disorders examined here, allowing the memory system to play compensatory roles across them. We then outline the main predictions of the compensation hypothesis, and examine the evidence for each of these predictions for each disorder. Finally, we discuss therapeutic, diagnostic, and other implications.

2. Declarative memory: what is it?

Traditionally, the declarative memory system has referred to the brain system that underlies the learning and storage of explicit knowledge, that is, knowledge that is available to conscious awareness. This includes explicit knowledge both about facts (semantic knowledge; e.g., that the capital of Swaziland is Mbabane) and about events (episodic knowledge; e.g., that you ate spicy tender but crunchy calamari at a Thai restaurant last night). However, accumulating evidence suggests that this brain system underlies much more, and that it can learn implicit as well as explicit knowledge, for a wide range of information, functions, and tasks, across cognitive domains and sensory modalities