



Semantic conflicts are resolved differently by adults with and without ADHD



Dorit Segal^{a,*}, Nira Mashal^b, Lilach Shalev^c

^aSchool of Education, The Hebrew University of Jerusalem, Jerusalem, Israel

^bSchool of Education and Gonda Multidisciplinary Brain Research Center, Bar Ilan University, Ramat Gan, Israel

^cSchool of Education and School of Neuroscience, Tel Aviv University, Tel Aviv, Israel

ARTICLE INFO

Article history:

Received 17 November 2014

Received in revised form 19 September 2015

Accepted 28 September 2015

Available online 27 October 2015

Keywords:

Conflict resolution

ADHD

Metaphor comprehension

Executive attention

Domain general mechanisms

ABSTRACT

Attention Deficit/Hyperactivity Disorder (ADHD) is a common neurobehavioral disorder characterized by various behavioral and cognitive difficulties. Previous studies indicated that children with ADHD have language difficulties, including difficulties in metaphor understanding but the relation between metaphor processing and specific cognitive functions needs further investigation. In the current study we examined how adults with and without ADHD resolve semantic conflicts between a metaphorical prime and a metaphorical or literal target sentence. Twenty-six adults with ADHD and 24 age-matched control participants underwent a thorough evaluation of neuropsychological skills, as well as assessment of various aspects of attention. Results suggested that people with ADHD were less efficient than controls in resolving conflicts between metaphorical and literal meanings of sentence pairs. In addition they showed deficient sustained attention and executive attention. Moreover, the ability to resolve semantic conflicts was related to semantic fluency in the ADHD group, but to executive attention in the control group. These findings emphasize the various specific difficulties of adults with ADHD and shed light on the different role of attention in the resolution of semantic conflicts among ADHD individuals as compared to controls.

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1. Introduction

Attention Deficit/Hyperactivity Disorder (ADHD) is a neurobehavioral disorder of childhood onset, characterized by inattention, impulsiveness, and hyperactivity. Language impairments are also common in children with ADHD (Tirosh & Cohen, 1998). These language deficits can co morbid with ADHD or be directly associated with the disorder (Westby & Watson, 2004). The most reported language deficits in children with ADHD are impairments in pragmatics, which can be defined as the use of language in social interaction (Prutting & Kirchner, 1987). Pragmatics includes discourse management (turn taking, initiation and topic introduction), narrative discourse (generating a narrative) and the use of figurative language (utterances that mean more than what is literally said) such as idioms and metaphors (Adams, 2002; Grice, 1989; Staikova, Gomes, Tartter, McCabe, & Halperin, 2013). Several studies found that children with ADHD display stereotyped conversation, and difficulties in relevant skills such as initiation, use of context, topic introduction, turn taking, and production of organized, accurate, and cohesive narratives (Bishop & Baird, 2001; Camarata & Gibson, 1999; Geurts & Embrechts, 2008;

* Corresponding author at: Tel Aviv University, PO Box 39040, Ramat Aviv, Tel Aviv 69978, Israel. Tel.: +972 77 9511340; fax: +972 3 6498996.
E-mail addresses: doritse@gmail.com (D. Segal), mashaln@mail.biu.ac.il (N. Mashal), lilachsm@tauex.tau.ac.il (L. Shalev).

Tannock, Purvis, & Schaghar, 1993). Some studies also indicated that children with ADHD have difficulties in understanding figurative language (Adachi et al., 2004; Bignell & Cain, 2007).

While the relation between discourse management (e.g., turn taking) and ADHD symptoms (e.g., impulsivity) is quite straightforward and intuitive, the relation between metaphor understanding and the behavioral and cognitive characteristics of ADHD requires further investigation.

Traditionally, metaphors have been treated as a rare and ornamental addition to literal language, but current research suggests that metaphors are common in everyday communication (Bowdle & Gentner, 2005). A metaphor is a way of understanding one concept in terms of another, establishing correspondence between concepts from disparate domains of knowledge. The comprehension of metaphors requires non-literal interpretation that extends beyond first order lexical and syntactic processing (Bowdle & Gentner, 2005; Eviatar & Just, 2006). One can distinguish between novel metaphors and conventional metaphors, with novel metaphors referring to expressions that one has not heard before (e.g., *crystal river*), and conventional metaphors (e.g., *time is money*) referring to expressions that are familiar and well known due to repeated use (Mashal & Faust, 2009). The current study focuses on the processing of conventional metaphors.

The psycholinguistic views of metaphor comprehension fall into two broad classes: comparison and categorization (Glucksberg & Haught, 2006). According to the comparison view, metaphors can be interpreted as similes. For example, the metaphor *time is money* can be rephrased to the simile *time is like money* and the interpretation of the metaphor requires identifying shared properties of time and of money (Bowdle & Gentner, 2005). In contrast, according to categorization theories, metaphors are understood via a categorization process. One of these theories is the class inclusion theory proposed by Glucksberg and Keysar (1990). According to this theory, in order to understand metaphors (e.g., *I am a night owl*), people construct an ad hoc super-ordinate category (e.g., *night creatures*) to which the metaphorical phrase (*night owl*) belongs. Gernsbacher, Keysar, Robertson, and Werner (2001) asked typically developed adult participants to read either metaphorical prime sentences, such as *That defense lawyer is a shark*, or literal prime sentences such as *That large hammerhead is a shark* and then asked them to verify a target statement (e.g., *Sharks are tenacious*). They found that verification latencies for statements relevant to the superordinate category (e.g., *Sharks are tenacious*) were faster after participants read the metaphorical prime sentences than after they read the literal prime sentences. In contrast, verification latencies for statements relevant to the literal meaning of the metaphor (e.g., *Sharks are good swimmers*) were slower following the metaphorical prime versus the literal prime sentence, producing a suppression effect. According to this model, in order to understand conventional metaphors, people must make an appropriate abstraction of the metaphor and inhibit its literal meaning (Gernsbacher et al., 2001; Nakamoto & Kusumi, 2005).

There is now a general agreement that metaphors can be processed either as comparisons or as categorizations (Bowdle & Gentner, 2005; Glucksberg & Haught, 2006) as a function of novelty, saliency and aptness. With regard to novelty, novel metaphors are always understood in terms of their corresponding similes, thus, through comparison processes. However, with repeated use, they are conventionalized and can be processed either by comparison or by categorization processes (Bowdle & Gentner, 2005). As to saliency, the graded salience hypothesis introduced by Giora (1997), posits a single processing mechanism for selecting among multiple meanings encoded in the mental lexicon, based on saliency. Salient meanings (e.g., conventional, frequent, familiar, enhanced by prior context) are processed first and only then do people process the less salient meaning. Thus, when processing a conventional metaphor such as *I am a night owl*, the salient figurative meaning (*awake at night*) is accessed directly, without having to process the less salient (literal) meaning (*having wings*). However, when processing novel metaphors, the literal meaning is the salient one and therefore is processed first, by comparison. Glucksberg and Haught (2006) further suggest that the degree of aptness which can be defined as the degree, to which a metaphor vehicle captures important features of a metaphor's topic, also influences processing. For example, the metaphor *The clue is a red herring* is conventionalized but not apt due to the weak semantic correspondence between the vehicle *red herring* and the topic *clue* (Thibodeau & Durgin, 2011). Novel metaphors can be less apt than conventional metaphors and therefore processed by comparison.

There is clinical evidence that people with different cognitive impairments including ADHD show deficiencies in the recognition and production of metaphors (Adachi et al., 2004; Bignell & Cain, 2007; Olofson et al., 2014), which raises the question regarding the cognitive mechanisms underlying metaphor processing. The comparison and the categorization processes can be treated as semantic conflicts between the relevant and the irrelevant meanings: The comparison process requires selecting the relevant shared properties and inhibiting irrelevant ones and the categorization process requires creating an abstract category while inhibiting the irrelevant basic literal category. Thus, the mechanisms underlying these processes probably include semantic as well as conflict resolution mechanisms.

Hussey and Novick (2012) suggested that in order to resolve a conflict, created by the presence of incongruent or mismatched information, participants must use cognitive control and override earlier formed interpretations. The cognitive control system, also called executive function includes "higher-level" cognitive functions involved in the control and regulation of "lower level" and goal directed behavior (Alvarez & Emory, 2006). Botvinick, Carter, Braver, Barch, and Cohen (2001) conceptualize cognitive control as a cluster of mental processes that allow individuals to adapt new rules and guide the selection of task-relevant over task irrelevant information in an environment that varies continuously. In other words, cognitive control includes conflict monitoring system which detects the occurrence of conflicts, evaluates the levels of conflicts, and then passes this information to the system that resolves the conflicts. Conflicts may vary in type and complexity. Hussey and Novick (2012) refer to this conflict resolution system as a domain general function that can operate over visual, spatial, or verbal domains. Besides conflict resolution, the executive function system includes a broad range of

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