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Executive functioning and verbal fluency in children with language difficulties

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ABSTRACT

This study provided a detailed analysis of verbal fluency in children with language difficulties, and examined the relative contributions of executive functioning (executive-loaded working memory, switching, inhibition) and language ability to verbal fluency performance. Semantic and phonemic fluency, language, and executive functioning tasks were completed by 41 children with specific language impairment (SLI) and 88 children with typical development. Children with SLI showed difficulties with most aspects of verbal fluency (rates of output, errors, switching) relative to typical children. Language ability predicted nearly every aspect of phonemic fluency performance and some aspects of semantic fluency performance. The relationships between verbal fluency and executive functioning were modest: inhibition was related to error scores on the phonemic fluency task, but relationships with executive-loaded working memory and switching were absent. Educationally, these results emphasise the underlying importance of language abilities in generation tasks like verbal fluency, but point to the importance of inhibition skills for error monitoring. Interventions to improve search and generation abilities have the potential to offer broader benefits in the classroom for children with language difficulties.

1. Introduction

1.1. Executive functioning and children with language difficulties

Executive functioning (EF) describes a constellation of related abilities involved in high-level, goal-directed behaviour/self-regulation (Miyake & Friedman, 2012) to enable negotiation of complex and changing circumstances in the absence of automatic or fixed ways of responding (Diamond, 2013). The most influential model of EF in adults (Miyake et al., 2000) identifies three components: executive-loaded working memory (ELWM: the ability to process and store information concurrently); switching (the ability to rapidly and flexibly change cognitive set); and inhibition (the ability to suppress readily available responses/stimuli). Identifying these areas of EF in children has been broadly successful, although some studies report two factors (Fisk & Sharp, 2004; Huizinga, Dolan, & van der Molen, 2006; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003; St Clair-Thompson & Gathercole, 2006; van der Ven, Kroesbergen, Boom, & Leseman, 2013), and recent conceptualisations have suggested inhibition might be part of a 'common' EF factor (Miyake & Friedman, 2012).

Children with developmental disorders show EF difficulties (e.g., ADHD, ASD: Corbett, Constantine, Hendren, Rocke, & Ozonoff, 2009; Geurts, Verte, Oosterlaan, Roeyers, & Sergeant, 2004), and the current study focused on children with specific language impairment (SLI). Although SLI is a controversial label (Bishop, 2014; Reilly, et al., 2014), researchers and clinicians agree that a heterogeneous group of children with significant language difficulties compared to their peers can be recognised (Reilly, Bishop, & Tomblin, 2014). The current study defined SLI as a developmental disorder involving delayed receptive and/or expressive language (phonology, vocabulary, grammar) in the absence of any obvious cause (Bishop & Norbury, 2008). Although exclusionary definitions can be controversial (Reilly et al., 2014), it is thought that SLI affects 3–6% of schoolchildren (Hulme & Snowling, 2009). Research classifying subgroups of children with different types/combinations of language difficulty has identified verbal sequential memory, speech production, lexical-semantic abilities and auditory conceptualisation factors (Van Weerdenburg, Verhoeven, & Van Balkom, 2006), but pinpointing stable subgroups over development is challenging

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(Conti-Ramsden & Botting, 1999; Reilly et al., 2014) and was, therefore, not attempted in the current study. We identified children diagnosed as having SLI and additionally checked that they also obtained poor scores on a standardised language test. The resulting sample is likely to have been heterogeneous in terms of language difficulties, comprising individuals with a range of expressive and receptive impairments. Although definitions of SLI no longer use 'cognitive referencing' (Bishop, 2014), we nevertheless ensured that the current sample of children with SLI had non-verbal IQ scores in the average range or above, so we could assess difficulties in verbal fluency without a potential confound of low IQ. A comparison sample included typical children with a similar range of chronological ages, but we included some younger typical children to reflect the lower 'language age range' of the SLI group. All comparison children were assessed to have no current language difficulties.

Children with SLI have difficulties with EF. Inhibition is impaired (Bishop & Norbury, 2005; Henry, Messer, & Nash, 2012; Im-Bolter, Johnson, & Pascual-Leone, 2006; Weyandt & Willis, 1994), and ELWM is also impaired in many children with SLI (see Montgomery, Magimairaj, & Finney, 2010 for a review; see also: Archibald & Gathercole, 2007; Ellis Weismer, Evans, & Hesketh, 1999; Henry et al., 2012; Im-Bolter et al., 2006; Marton, 2008; Marton & Schwartz, 2003; Montgomery, 2002). Current developmental conceptualisations of ELWM suggest increases in short-term memory (STM) and processing speed are implicated for typical children (Bayliss, Jarrold, Baddeley, & Leigh, 2005), and both STM and processing speed (general or specific to linguistic tasks) are indeed weak in children with SLI: (STM: Bishop, North, & Donlan, 1996; Dollaghan & Campbell, 1998; Edwards & Lahey, 1998; Gathercole & Baddeley, 1990; Hick, Botting, & Conti-Ramsden, 2005; processing speed: Leonard et al., 2007). Archibald and Gathercole (2007) argued persuasively that both phonological storage and EF are impaired in children with SLI. The only major unimpaired EF area in children with SLI is switching (Dibbets, Bakker, & Jolles, 2006; Henry et al., 2012; Im-Bolter et al., 2006; Kiernan, Snow, Swisher, & Vance, 1997; Weyandt & Willis, 1994; but see Marton, 2008). The current study examined all three areas of EF to assess their relationships to verbal fluency in a mixed sample of children with and without SLI.

1.2. Verbal fluency and executive functioning

Verbal fluency tasks assess "strategic search and retrieval processes from the lexicon and semantic memory" (Sauzéon, Lestage, Raboutet, N'Kaoua, & Claverie, 2004). They require generation of as many words as possible within 1 min according to simple rules that target sounds (phonemic fluency, items starting with particular letters such as "f", "a", "s") or semantic categories (semantic fluency, "animals" or "foods") (Troyer, 2000; Troyer, Moscovitch, & Winocur, 1997). These two tasks measure related processes in adults (Unsworth, Spillers, & Brewer, 2011) and are correlated in children (Matute, Rosselli, Ardila, & Morales, 2004; Riva, Nichelli, & Devoti, 2000). Successively generated items are often related to each other along task-relevant dimensions: e.g., phonemic fluency relationships via spelling-sound knowledge; or semantic fluency relationships via associative links in long-term/semantic memory (Seidenberg, 2005). Hence, verbal fluency tasks are an important window into children's' lexical/semantic/phonemic networks and strategic search and retrieval processes (Sauzéon et al., 2004). As might be expected, verbal fluency abilities improve with age in typical children (Hurks et al., 2010; Kavé, 2006; Kavé, Kigel, & Kochva, 2008; Klenberg, Korkman, & Lahti-Nuuttila, 2001; Korkman, Kemp, & Kirk, 2001; Matute et al., 2004; Riva et al., 2000; Sauzéon et al., 2004).

Verbal fluency is often described as a measure of EF (Pennington & Ozonoff, 1996), and has been related to executive dysfunction after neurological damage (Henry & Crawford, 2004) because it requires goal-directed behaviours such as flexibility of thought, strategic planning, non-habitual responses and error-monitoring. Diamond (2013) suggested verbal fluency reflects one aspect of cognitive flexibility. Contrastingly, verbal fluency has been regarded as a language measure and related to lexical access (semantic and phonological retrieval processes), language proficiency, vocabulary size (Luo, Luk, & Bialystok, 2010), and vocabulary knowledge (Prigatano & Gray, 2008; Ruff, Light, Parker, & Levin, 1997). Importantly, children with SLI (Weckerly, Wulfeck, & Reilly, 2001) and those with other language difficulties (dyslexia: Cohen, Morgan, Vaughn, Riccio, & Hall, 1999; deaf signers with SLI: Marshall, Rowley, Mason, Herman, & Morgan, 2013; word finding difficulties: Messer & Dockrell, 2013; Down Syndrome: Nash & Snowling, 2008) show difficulties with verbal fluency.

The current study had two aims. (1) To explore whether verbal fluency performance limitations in children with SLI can shed light on underlying difficulties. (2) To test current theoretical conceptualisations of the relative roles for EF and language ability in *predicting* verbal fluency performance. These two issues are reviewed below.

1.3. Aim 1: What does verbal fluency reveal about children with language difficulties?

Verbal fluency is a multifactorial task requiring a range of performance factors (Troyer et al., 1997). Generating items according to a rule taps the ability to search and retrieve relevant information from lexical/semantic memory (Kavé et al., 2008), particularly, the ability to retrieve phonological and semantic information (Marshall, 2014). It reflects monitoring of output for errors/rule violations (Unsworth et al., 2011), and provides information about the organisation of and access to semantic/phonemic networks (Nash & Snowling, 2008; Weckerley et al., 2001). These are highly relevant and generalizable skills/abilities in the classroom, involved in learning activities whereby organised, stored information on a range of topics (e.g., chemistry, history, physics, languages etc.) is accessed and retrieved according to relevant dimensions and monitored for accuracy/relevance.

These processes were investigated in detail. Total number of items generated in phonemic and semantic fluency tasks assessed ability to search for, retrieve and generate information from semantic/phonemic networks ('total output'). Correct items ('valid output') within task rules may be more relevant to classroom learning, demanding refined searches, careful response selection and ongoing monitoring for accuracy. Further, to gain insight into accuracy monitoring, errors were assessed. Previous work (Weckerly et al., 2001) reported that children with SLI produced fewer responses, but showed no differences in numbers of overall errors, suggesting difficulties with search, retrieval and generation of items, not with monitoring failures. However, Weckerley et al.'s (2001) measure of total errors did not account for overall level of performance, so a *proportion* of errors measure was calculated here.

Verbal fluency tasks are powerful methods of assessing switching between clusters of related items (Troyer et al., 1997). Although EF switching abilities appear preserved in children with SLI (see earlier), in such tasks, categories are detected from visual cues (e.g., Wisconsin Card Sorting Task). Verbal fluency switching requires *self-generation* of new sub-categories with no cues. Children with SLI may be less able than typical children to self-generate relevant categories and to switch between 'exhausted' subcategories of target items. This could reflect less extensive or well-organised semantic/phonemic networks, limited semantic/phonemic/lexical knowledge (having fewer subordinate categories available) (Nash & Snowling, 2008), and/or reduced efficiency in